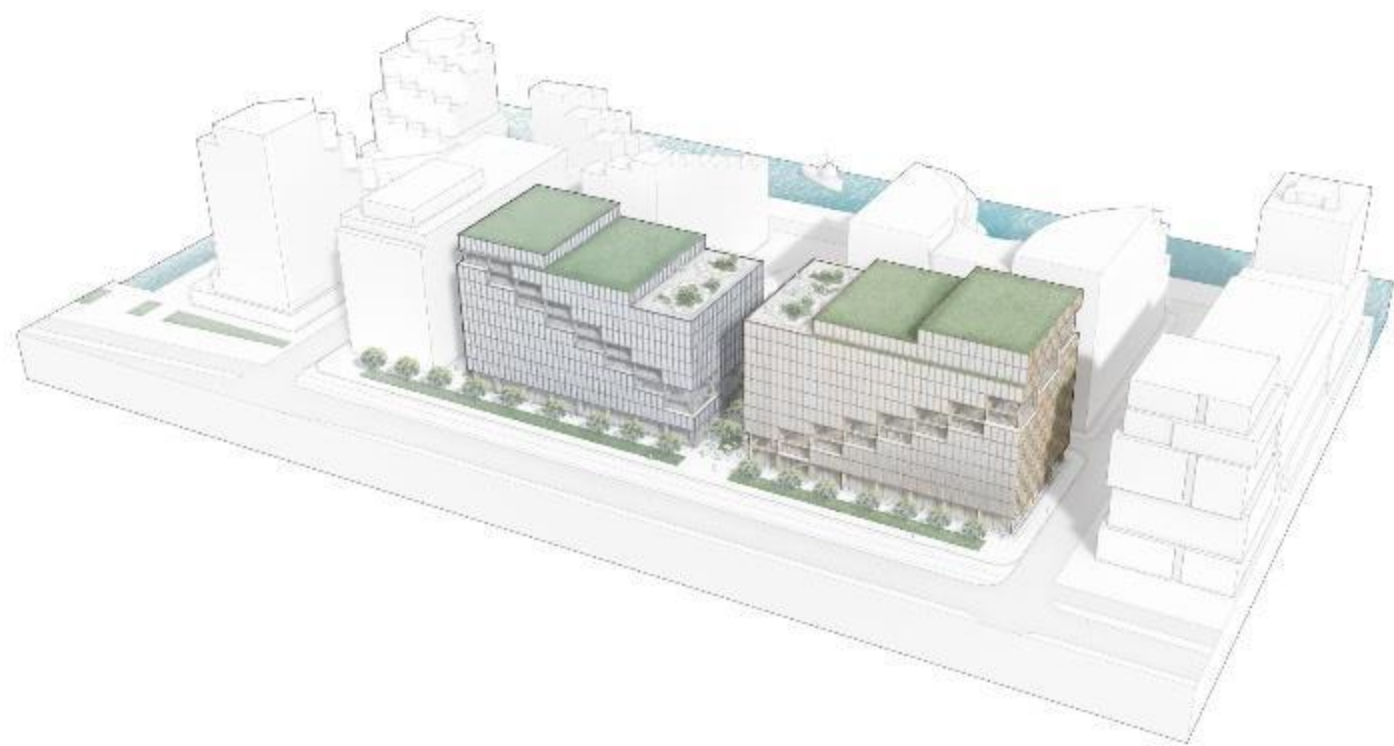


# **BUILDING A CIRCULAR FUTURE**

Kasper Guldager Jensen, [kgj@3xn.dk](mailto:kgj@3xn.dk), [www.3xn.dk](http://www.3xn.dk), +45 6120 1784







### Cross Laminated Timber (CLT)

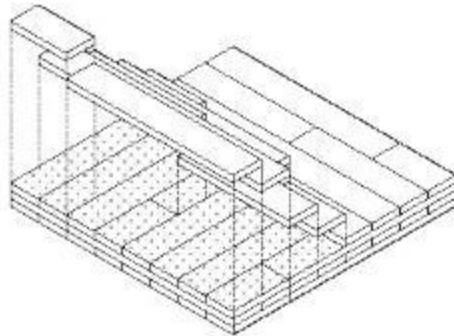
The wooden structure is built in Cross Laminated Timber, which is both a very strong and efficient building material and at the same time it has a very low environmental and climate impact during production. This will also give the interior of the building a unique and characteristic expression that reflects the character of the exterior. Both the wood itself and the shape of the wooden frame ensure good acoustics and generally a healthy and comfortable indoor climate.

### Bio-treated timber

The materials we use for our buildings should be toxin free and support our health. Not just for ourselves, but also for future generations that will have to utilize the materials and solutions we develop today. Utilising a formaldehyde-free bioglut in the CLT ensure a healthy indoor climate whilst also protecting the environment. Treating the timber with a natural impregnation

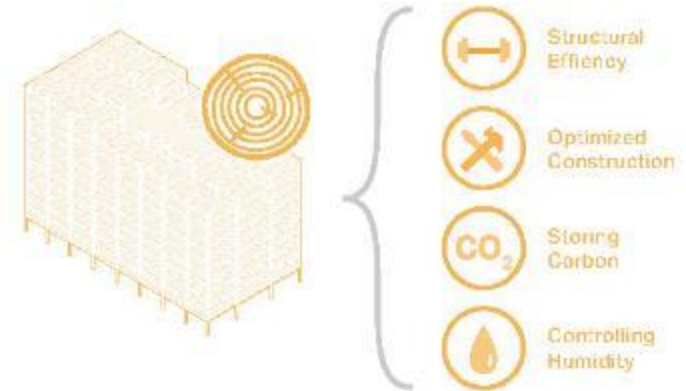


Bio-treated timber used in large scale on an arena in Copenhagen, Denmark.



CLT is produced by crossing and gluing smaller pieces of wood

### Value Creation



#### Structural Efficiency

Timber is the structurally most efficient material by weight. It thereby requires less resources to handle during the construction phase and the lighter material also requires less foundation.

[Large-Span Timber Structures — Roberto Cecchi, 2016]

#### Optimised construction

Timber construction only takes 2/3\* the construction time of traditional concrete buildings and requires only 1/5\* of the transport

[Berlin keynote — Bente Madsen, 2016]

#### Storing Carbon

For every dry tonne of timber produced, 1,8 tonnes of carbon dioxide is taken from the atmosphere. Timber is a renewable material. When a tree is felled a new can grow in its place.

[Timber in the carbon economy — Timber NSW, 2018]

#### Controlling Humidity

Wood is breathable and can absorb and release moisture. It creates a naturally regulated indoor climate.

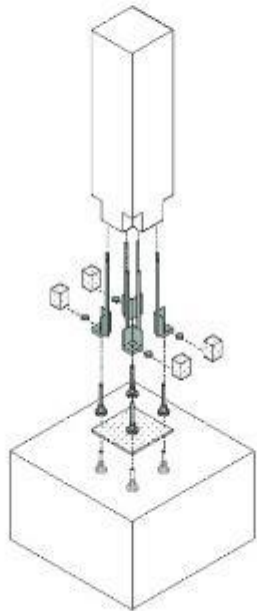
[Wood handbook — US Department of Agriculture Forest Service, 2010]

### Reversible connections

Mechanical and reversible joints and easily dissolvable binders between concrete elements, are implemented to allow for easy assembly and disassembly. This is making a second life for the materials as well as easy maintenance possible.

### Upcycle concrete

Concrete is a CO<sub>2</sub>-expensive building material. It is among other things the production of cement that pays the environment and contributes negatively to the greenhouse effect. Cement contributes with approx. 6% of total man-made CO<sub>2</sub> emissions in the world.

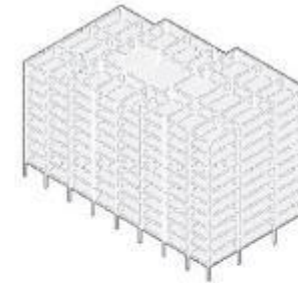


Upcycled concrete with aggregates of reused concrete.



All the concrete elements are joined by bolted steel connections, all reversible reusable in the future.

### Value Creation



#### Ready for Circular Economy

Earn 4% of the new build value on the superstructure and envelope by designing it for disassembly.

(Building a Circular Future — GUN, 2016)

#### Thermal performance

Concrete acts as a heat store. This enables cost savings to be made in energy requirements with a reduction in the need for heat generation.

(A sustainable construction products dilemma — Molleam, 2013)

#### Cheap Insurance

Insurance rates for concrete frame buildings are 14 to 65% less than for timber frame structures.

(Underwriters aware of the risks of wood-frame construction: Survey — Insurance Business America, 2017)

#### Fast Construction

Making a bolted connection takes 15 to 20 minutes — it's 3 to 4 times faster when compared to traditional concrete construction methods.









**WHAT IS THE PROBLEM?**

CONCRETE IS CHEAP AND DURABLE  
BUT ALSO THE BIGGEST CO2 EMITTER

WHAT IS THE SOLUTION?

CIRCULAR ECONOMY IS  
ABOUT THE ECONOMY



89%





2%

**WE NEED TO TALK ABOUT  
THE BUSINESS CASE**



**Advisory Board for  
cirkulær økonomi**

## Anbefalinger fra Advisory Board for cirkulær økonomi Fremtidens Forretning



Advisory Board for  
cirkulær økonomi

### Advisory Board for cirkulære økonomi består af:



**Flemming Bøenbacher  
(formand)**  
Bestyrelsesformand,  
Carlsberg Group



**Aja Guldhammer**  
CEO, Reshopper



**Anders Byrtel**  
CEO, Kvadrat



**Pernille Blach Hansen**  
Senior Director, LEGO



**Christian B. S. Christensen**  
CEO, Solum Gruppen



**Mik Kristensen**  
CEO, Nykredit Leasing



**Franz Gucliza**  
CEO, Aage Vestergaard Larsen



**Martin Petersen**  
CEO, EcoXpac



**Matias Mol Dalsgaard**  
CEO, GoMore



**Jais Valeur**  
CEO, Danish Crown



**Kasper Guldager**  
CEO, GXN



**Jeanett Vilkkelsoe**  
COO/CFO, Marius Pedersen





2015



2065

Shanghai 1987

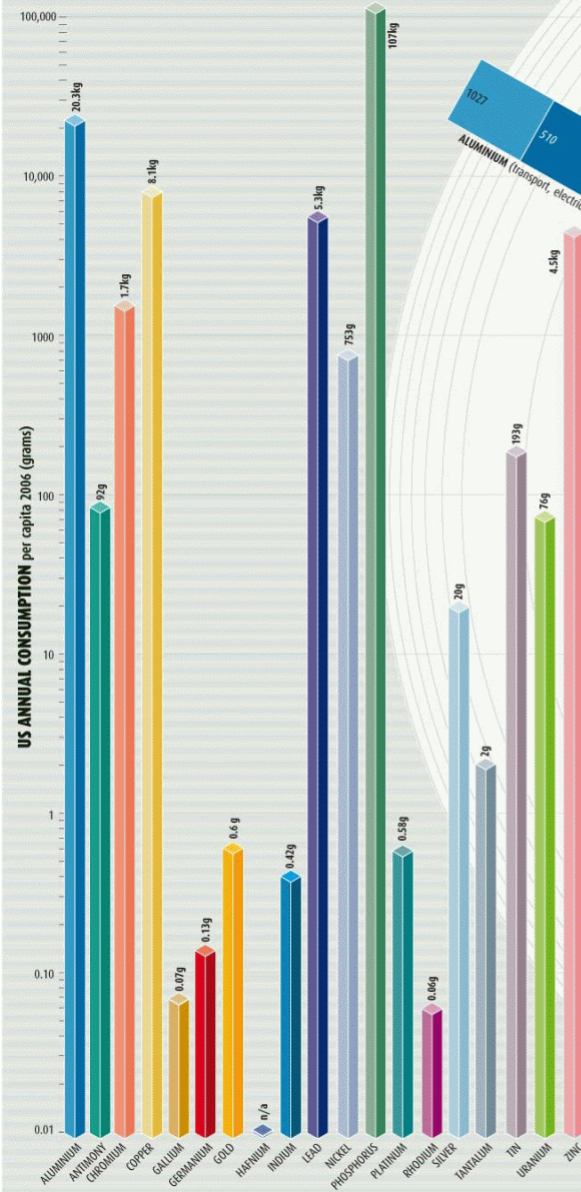


Shanghai 2013





# HOW LONG WILL IT LAST?

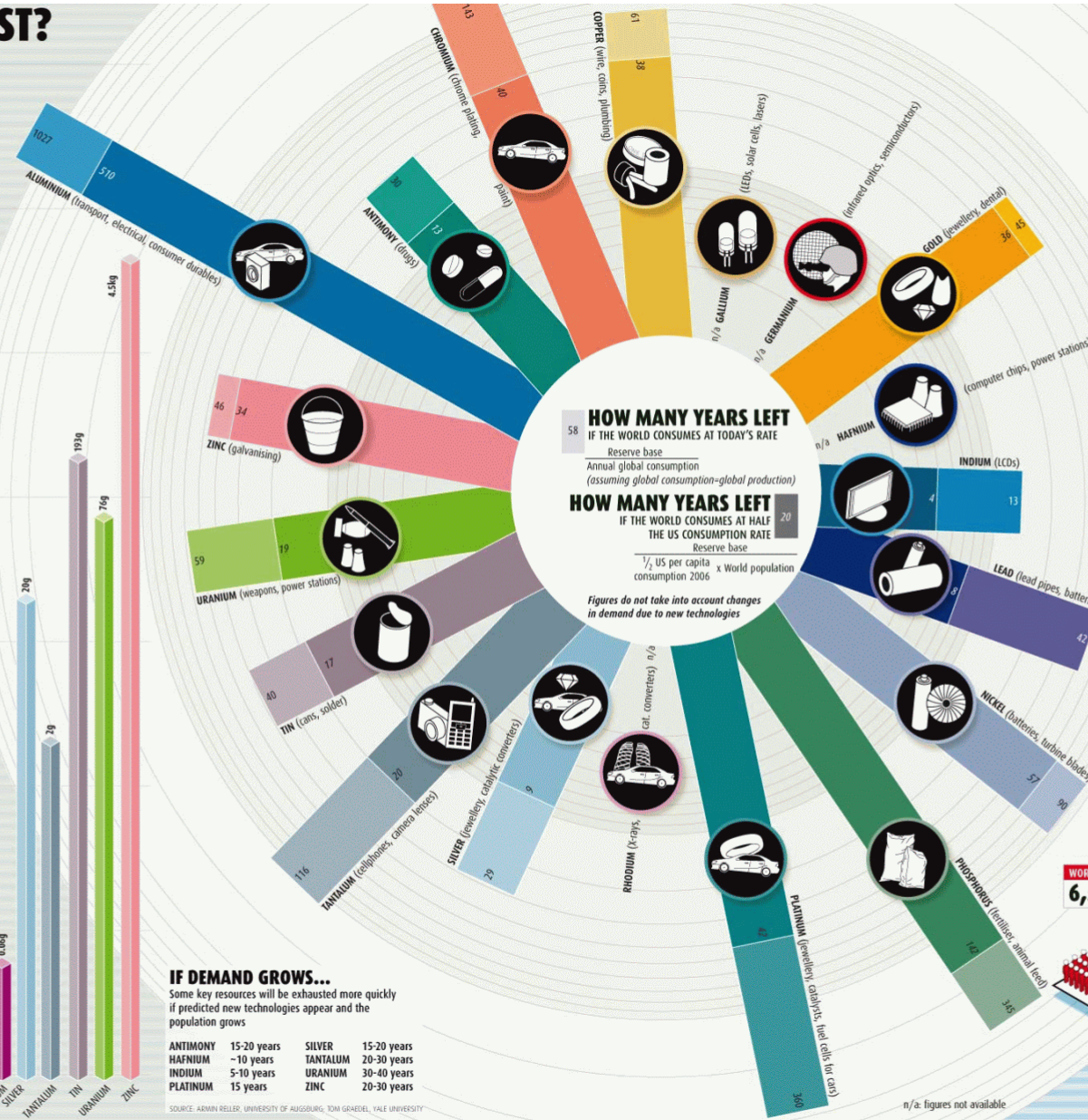


## IF DEMAND GROWS...

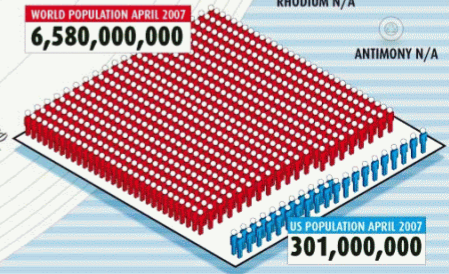
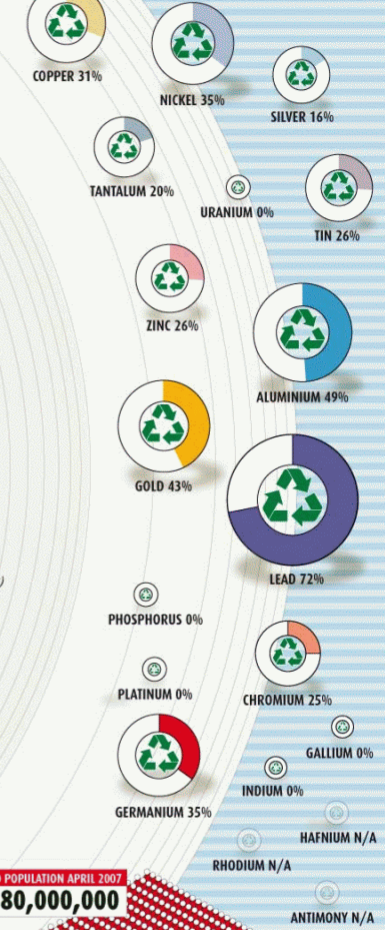
Some key resources will be exhausted more quickly if predicted new technologies appear and the population grows

ANTIMONY	15-20 years	SILVER	15-20 years
HAFNIUM	~10 years	TANTALUM	20-30 years
INDIUM	5-10 years	URANIUM	30-40 years
PLATINIUM	15 years	ZINC	20-30 years

SOURCE: ARMIN RELLER, UNIVERSITY OF AUGSBURG; TOM GRADEL, YALE UNIVERSITY



## PROPORTION OF CONSUMPTION MET BY RECYCLED MATERIALS (%)



n/a: figures not available

Adopting circular-economy principles will not only benefit Europe environmentally and socially but could also generate a net economic benefit of €1.8 trillion by 2030.

McKinsey  
&Company

# 3XN Architects Copenhagen















SEAFOOD

SYDNEY FISH MARKET





## How can a building adapt to social and programmatic fluctuation?

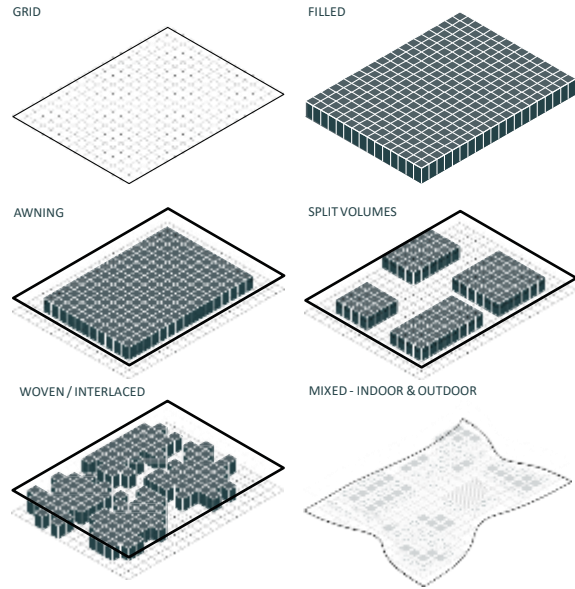


Figure : Modular Building System & Capabilities

A modular framework underpins the functional strategies of the facility and enables representation and ownership of stakeholders and user groups. The flexibility of the modular system enables spaces and places to overlap, change shape and form, to create new and diverse zones for different operations under the one roof.

It allows for interior and exterior spaces to flex, grow and shrink as needs require. It gives each module, or group of modules within to develop its own identity based on the requirements of a specific situation. The building becomes a responsive element that changes to meet the current and future needs of the various user groups and stakeholders.

## Diverse Experiences



Figure : Building Grid Module

Figure : Introduce Functionalities

Figure : Create Floor Surface Experience

Figure : Create Roof Surface Experience

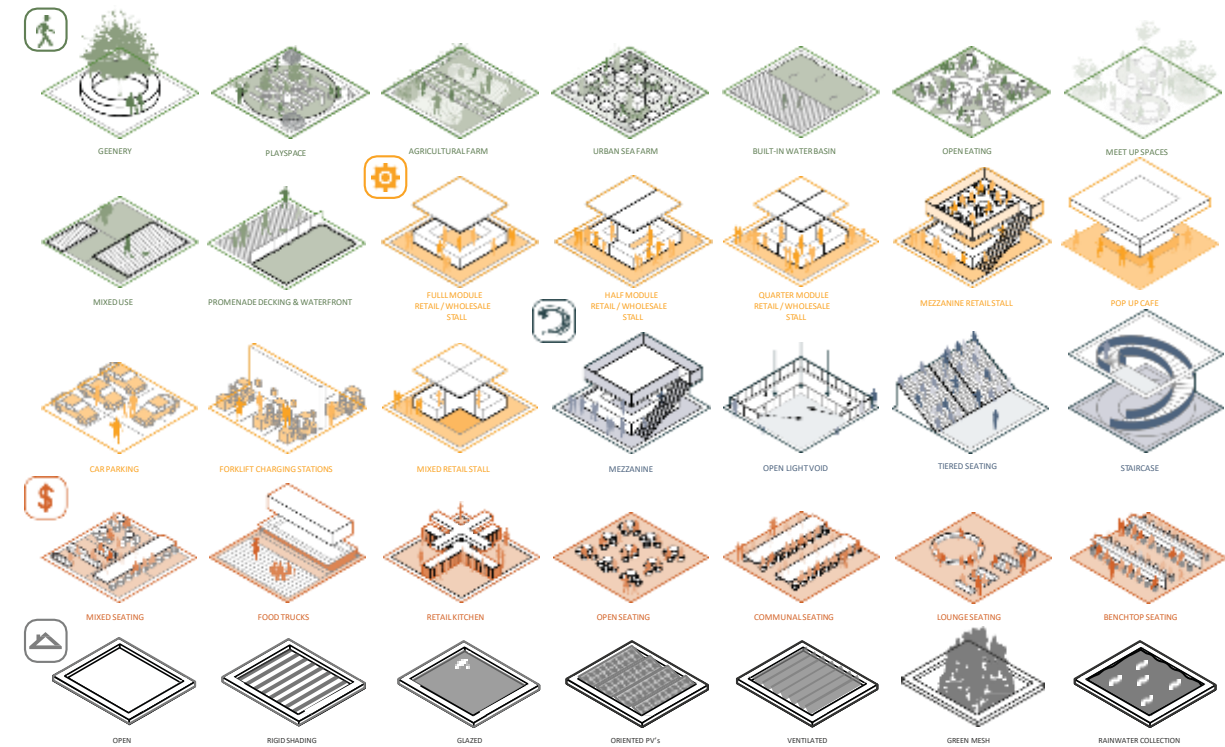
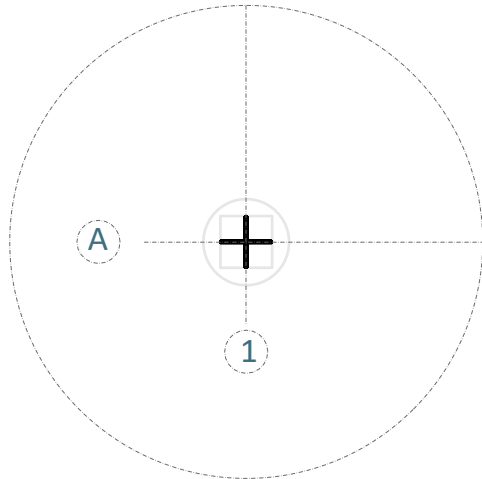


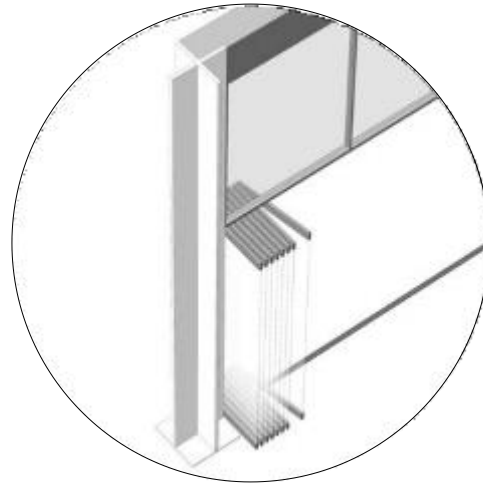
Figure : Potential Ground & Roof Surface Functionalities and Scenarios

# Modular Concepts

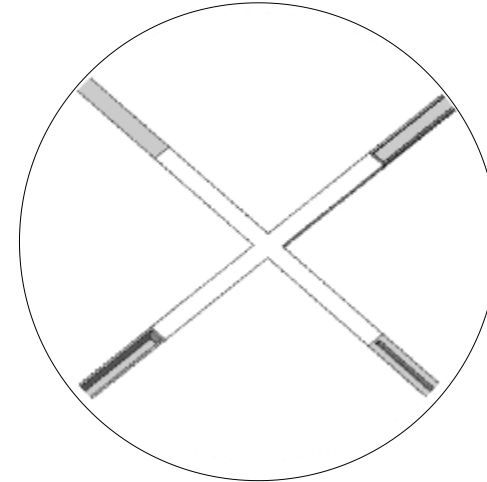
Modular features intersecting with structural column



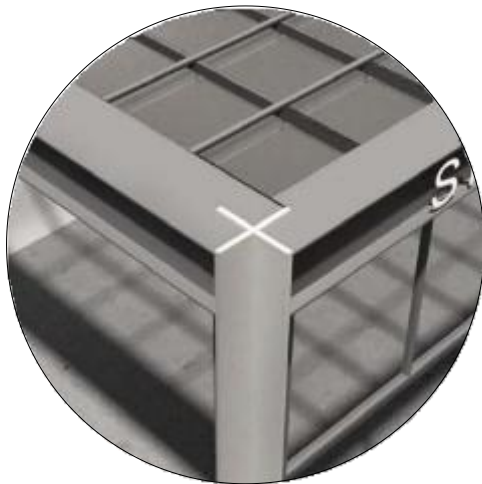
PLAN RELATIONSHIP TO GRID



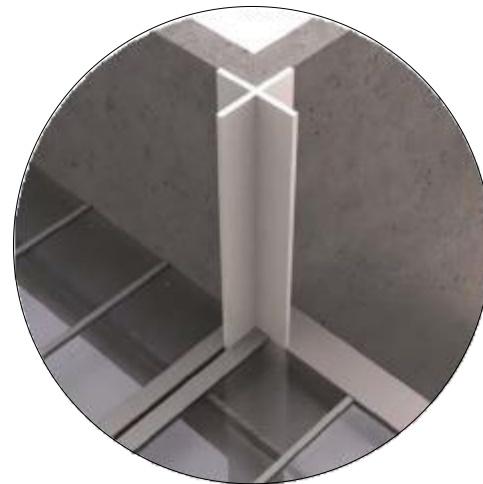
FACADE TO COLUMN CONNECTION



FLOOR WITH MULTIPLE CHANNEL TYPES



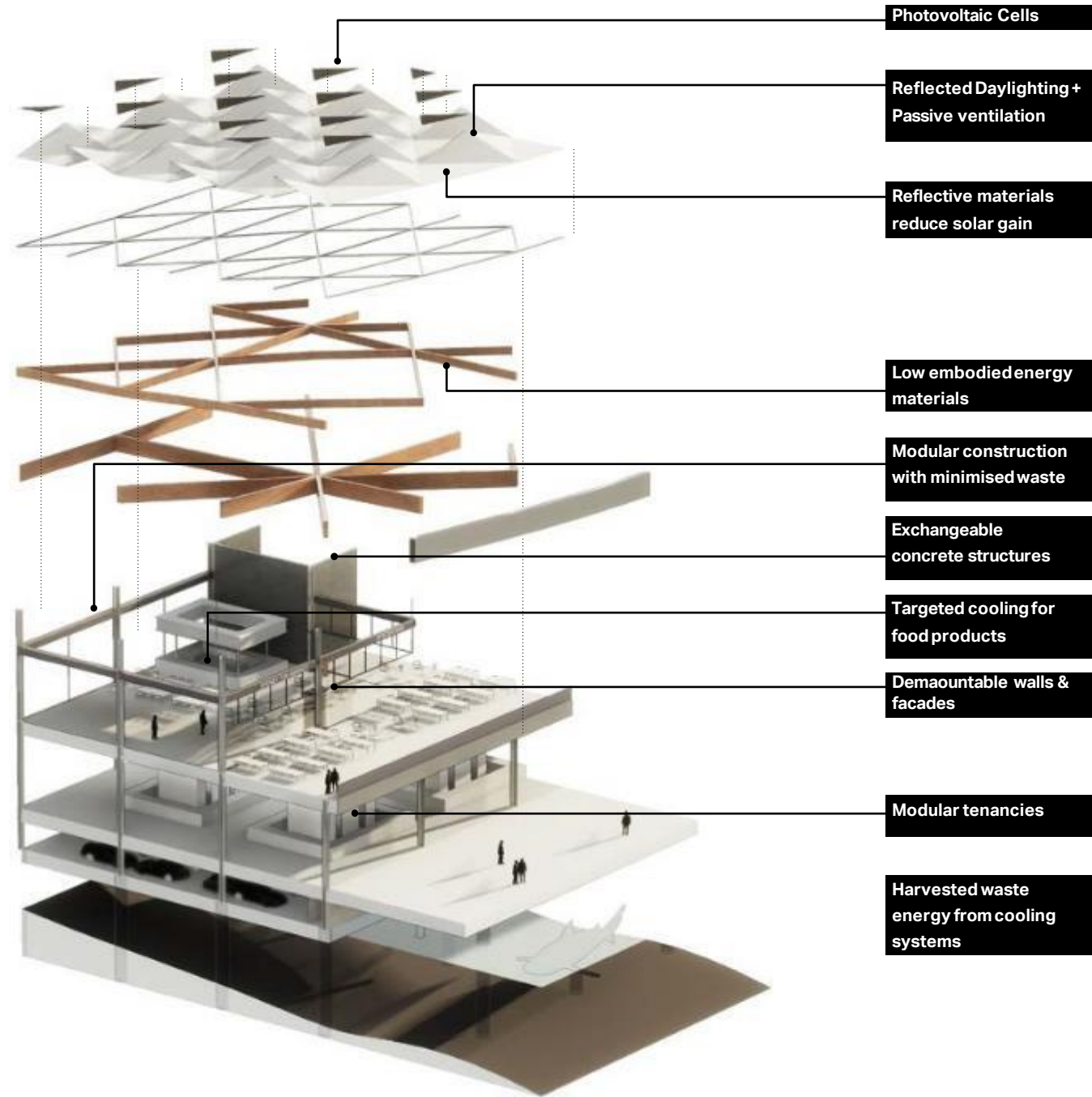
COLUMN TO SIGNAGE BEAMS & GLASS CEILING



CORE TO COLUMN & ROOF CONNECTION



COLUMNS WITH INTEGRATED PROFILES FOR ROLLERS



**3XN**  
architects

**GXN**  
innovation





RESEARCH

PROJECT DESIGN

COMPETITION



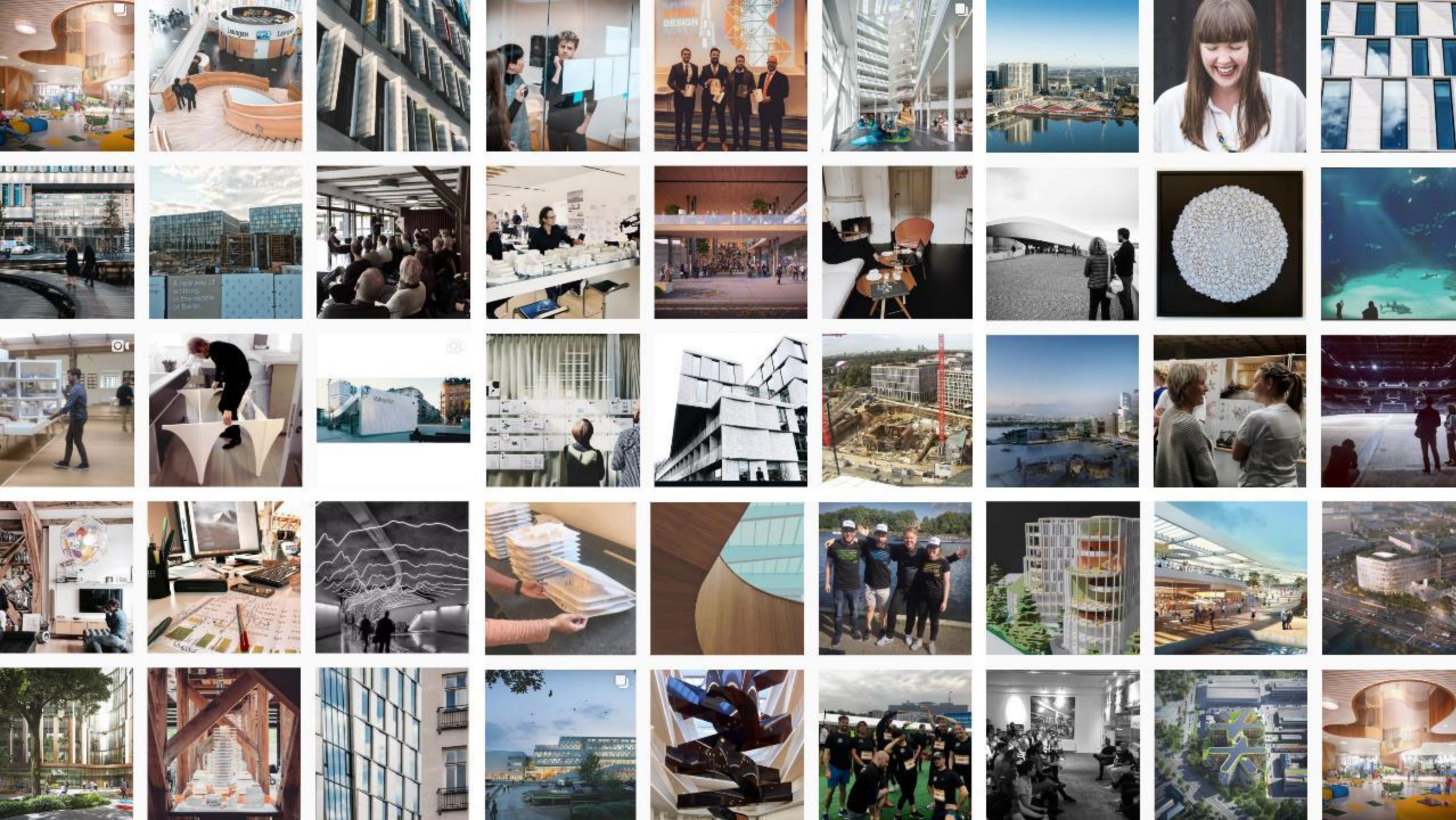
**3XN**  
architects



**GXN**  
innovation

ANTHROPOLOGIST  
ARCHITECTS  
BIOLOGIST  
BUSINESS DEVELOPERS  
COMPUTATIONAL DESIGNERS  
ENGINEERS  
GRAPHIC DESIGNERS  
INTERIOR ARCHITECTS  
MODEL BUILDERS  
PSYCHOLOGIST  
URBAN PLANNERS





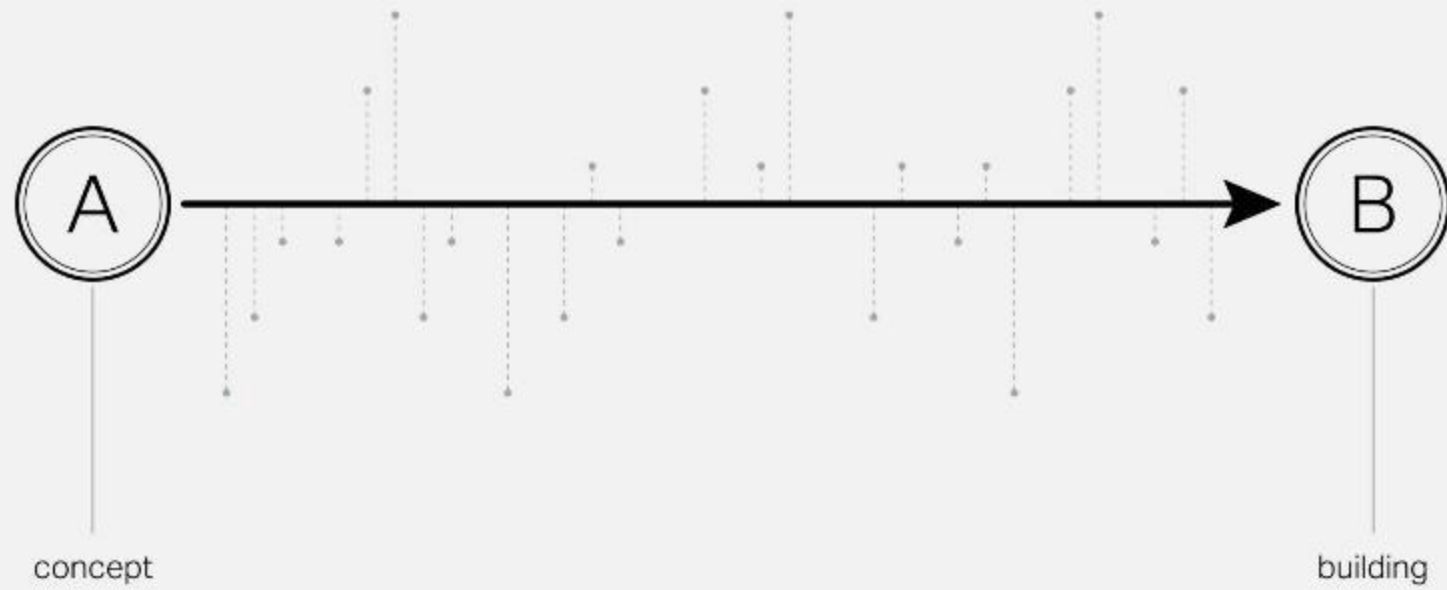


**3XN**

**+**



**GXN**





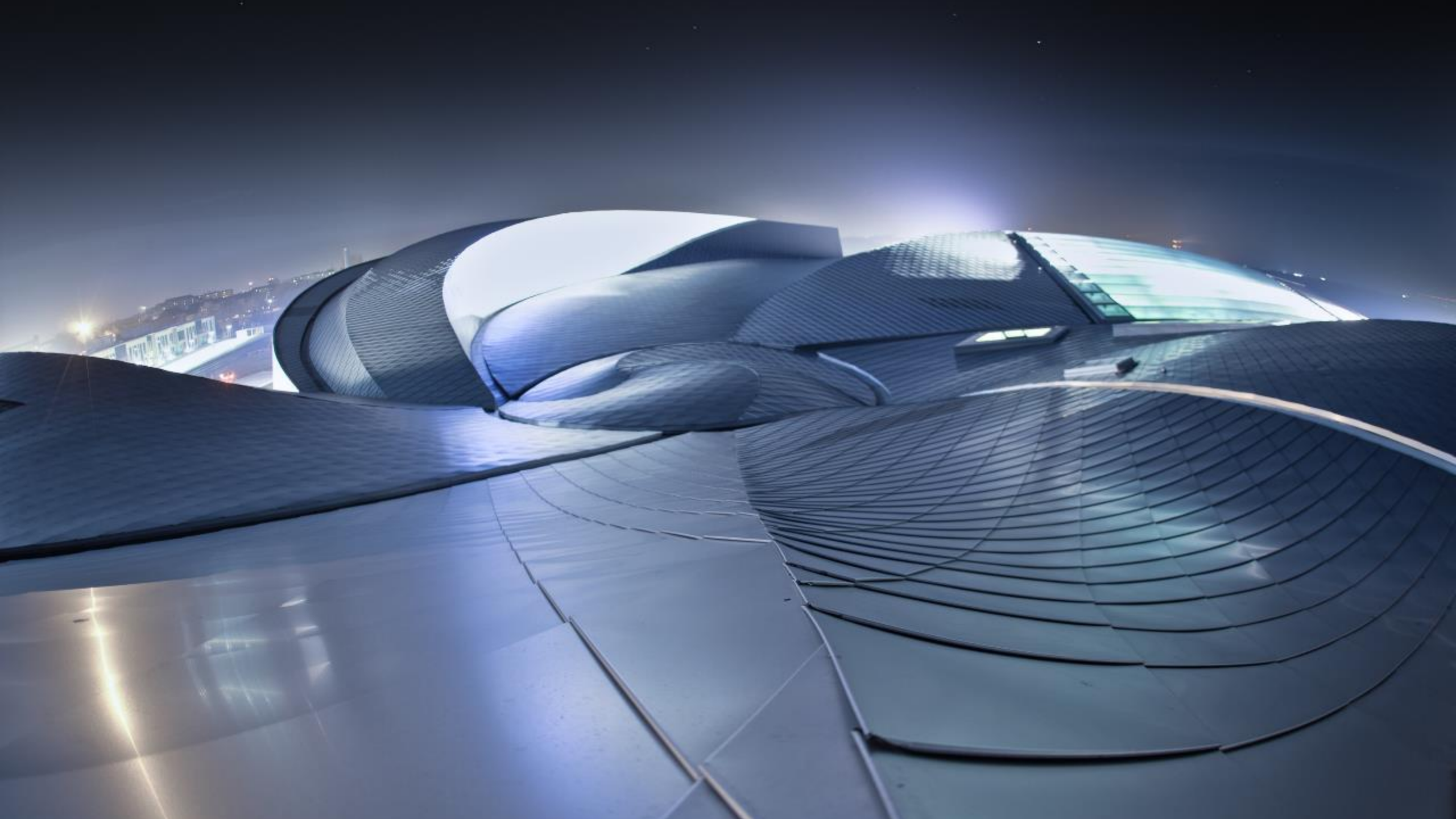
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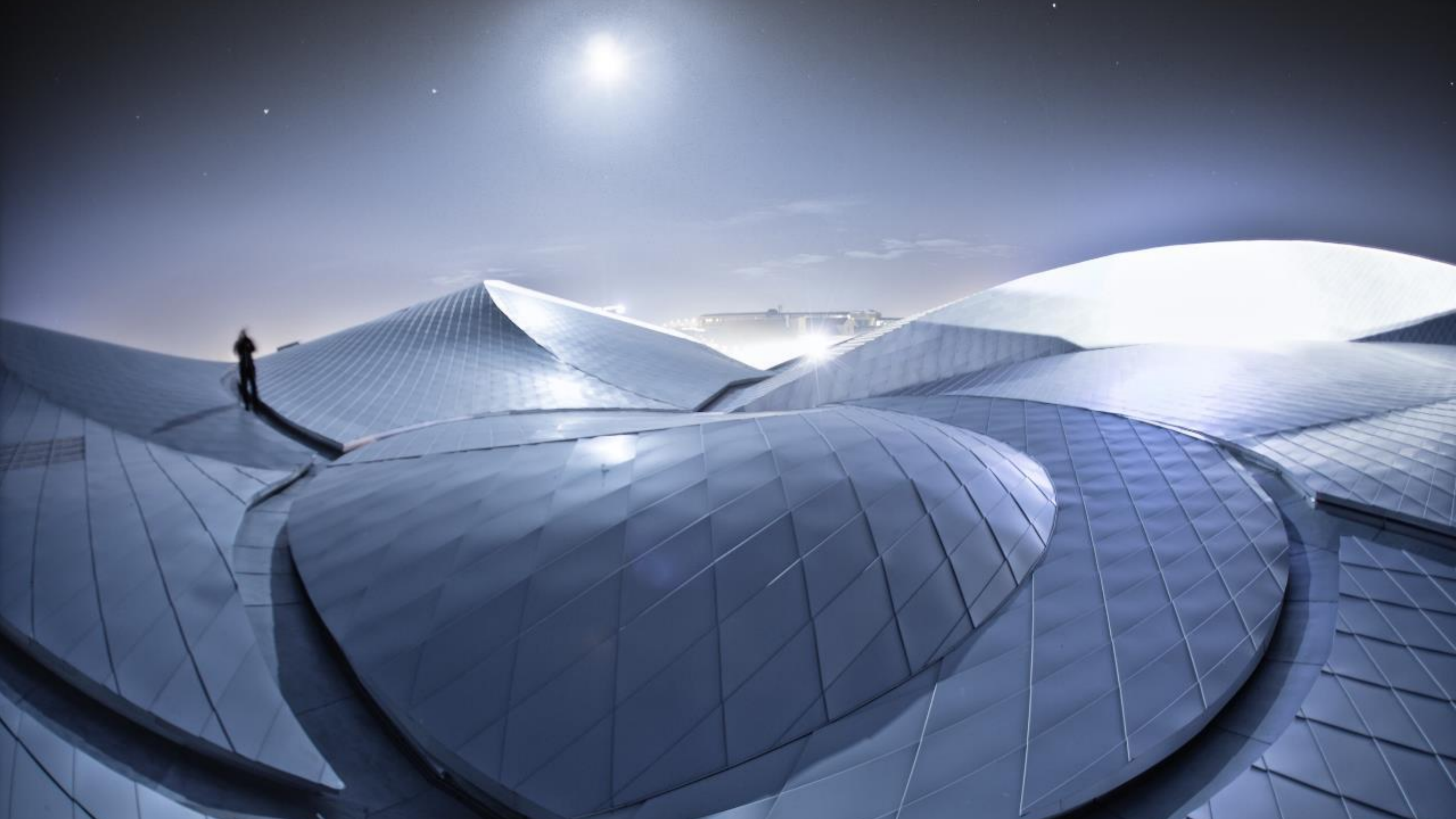
concept



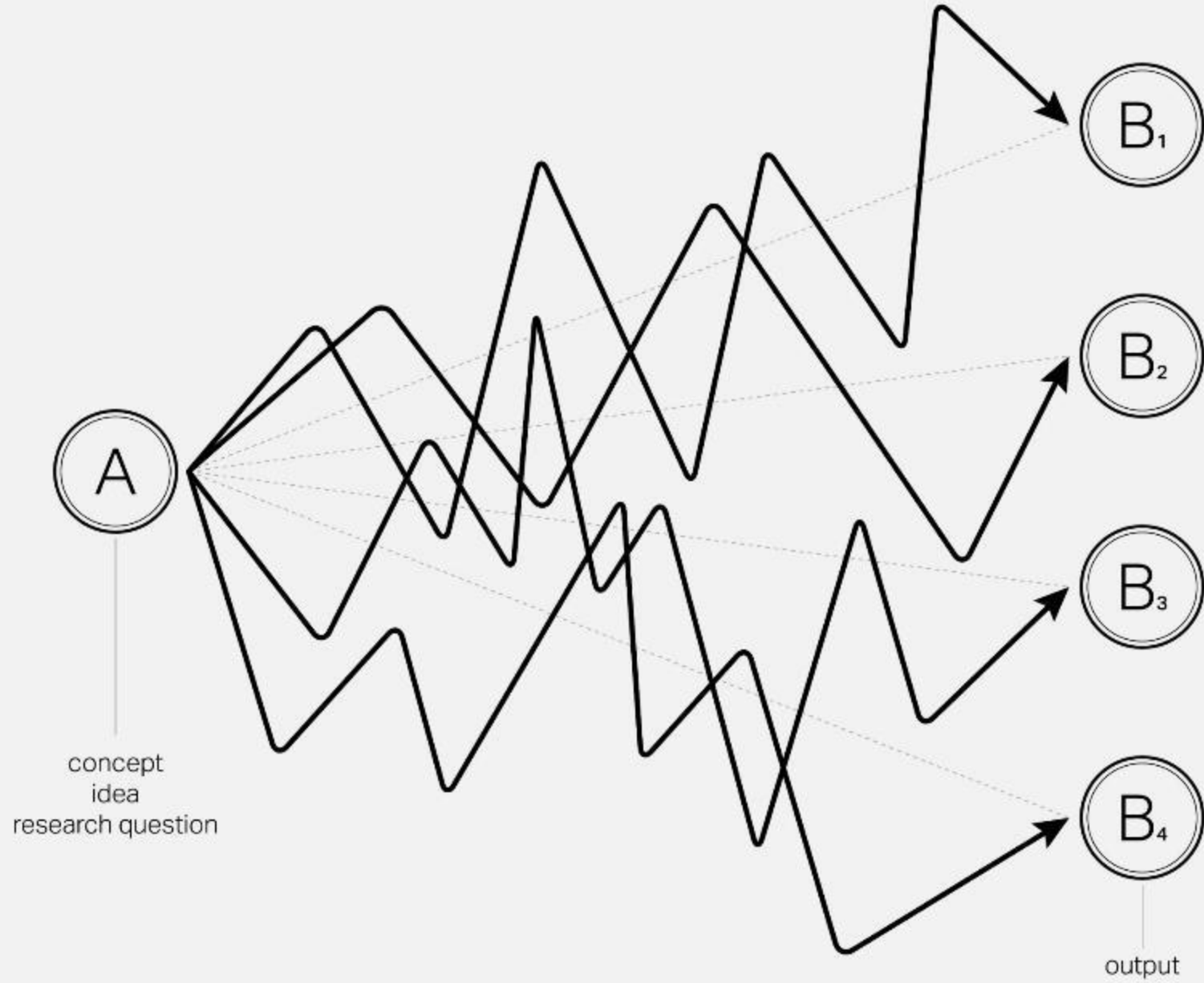
B

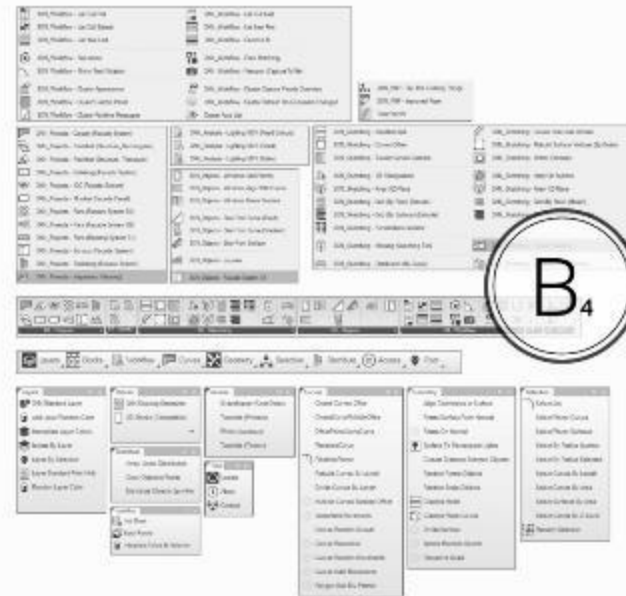
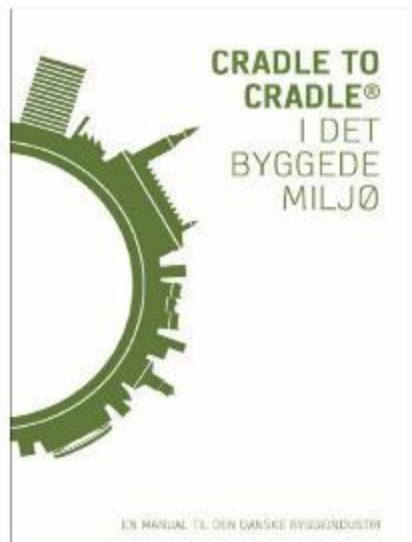
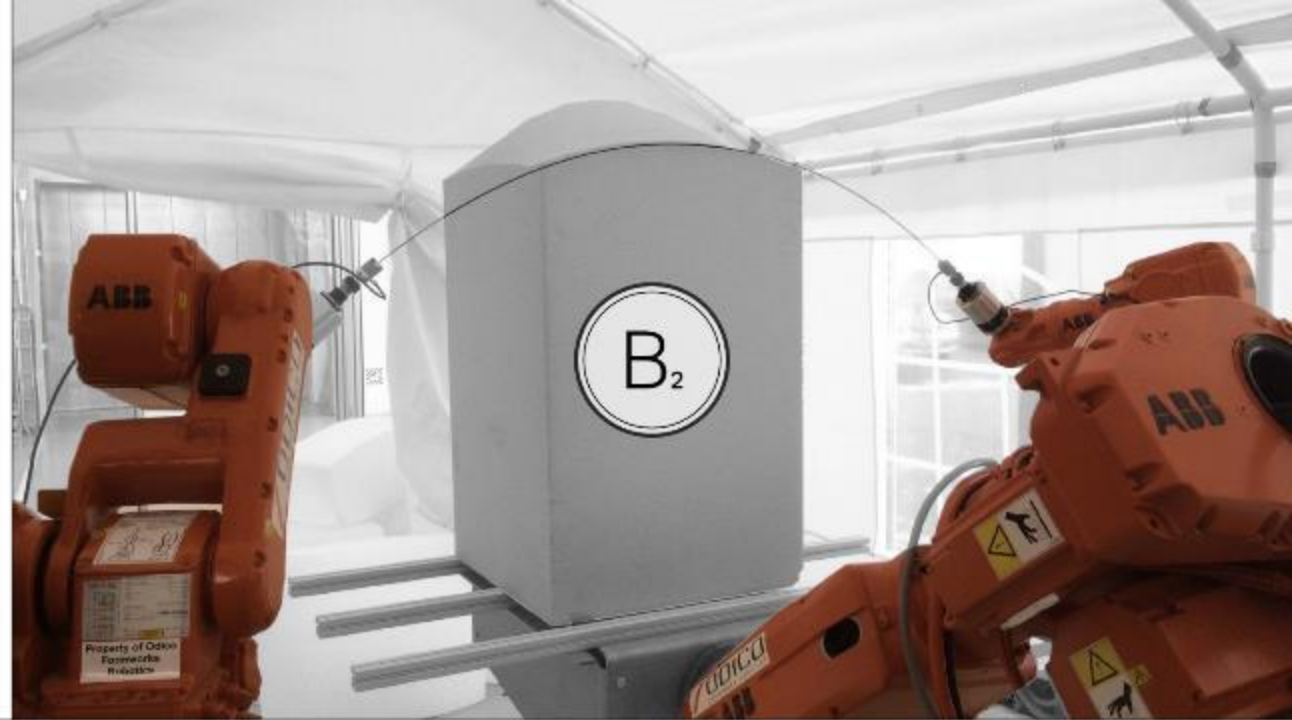
building





















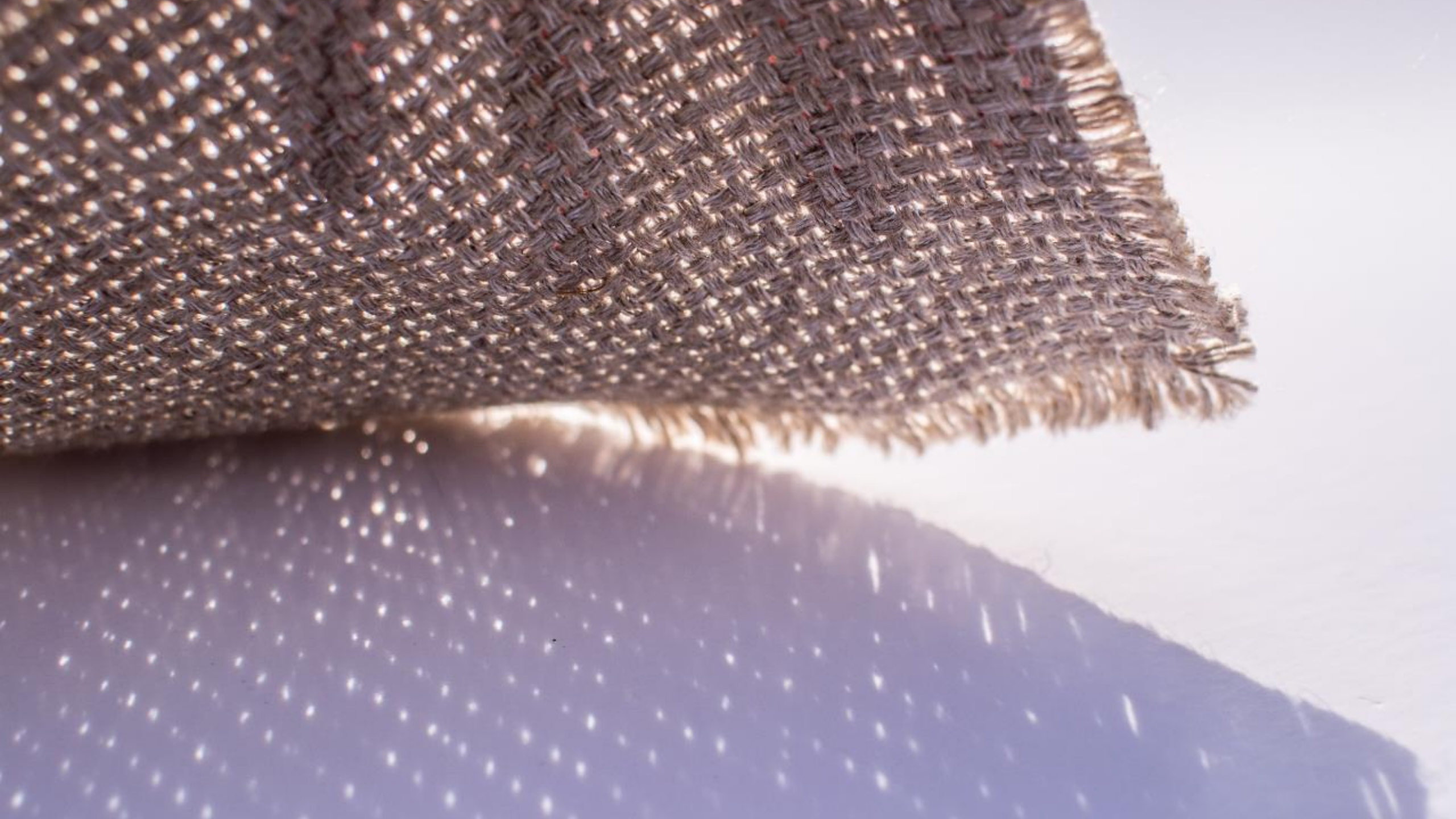




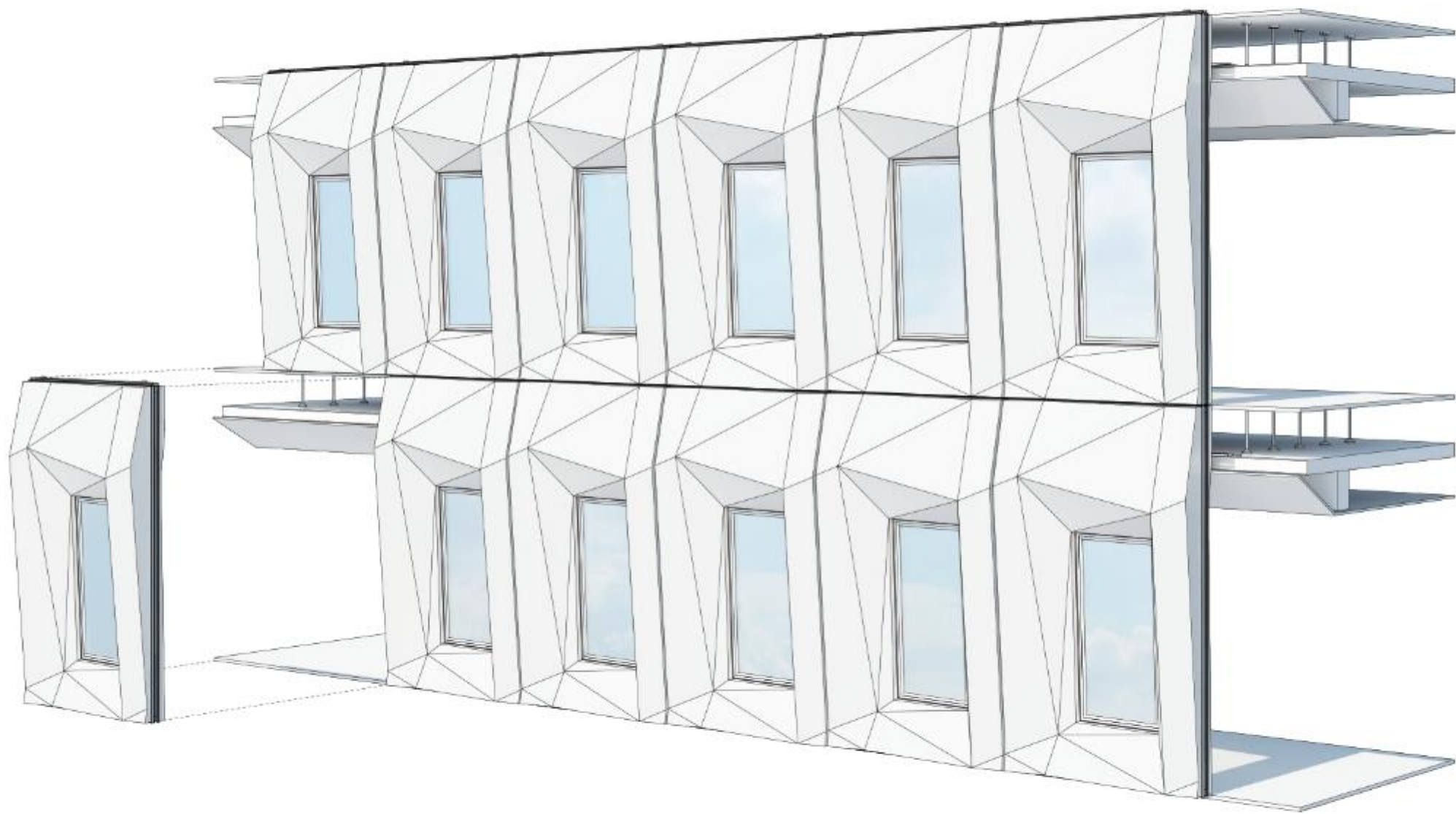










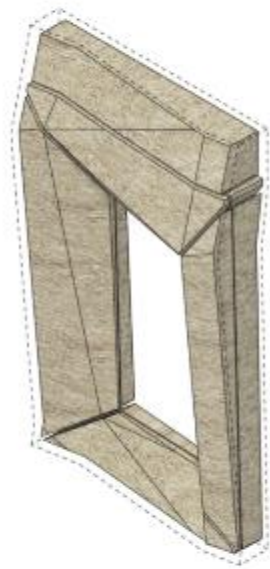




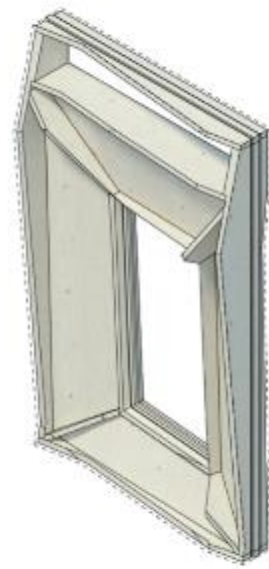
*External glass window*



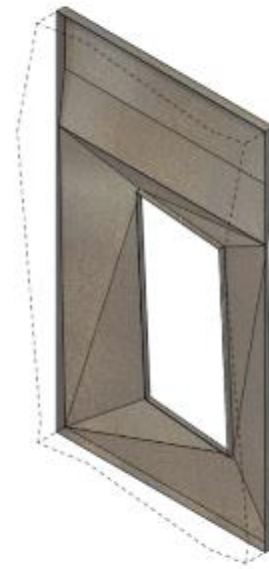
*Bio-composite exterior*



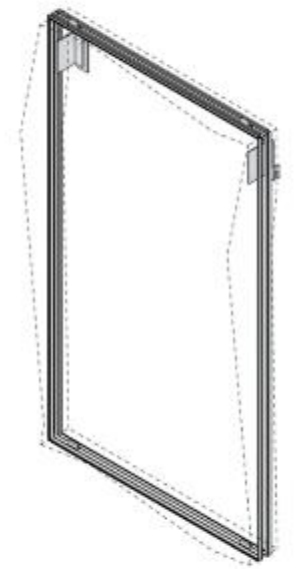
*Wood-fibre insulation*



*Internal wood structure*



*Bio-composite interior*



*Aluminium interface*









**Material  
World**







Smart Materials  
00-19

# 15

## Micronal Smart Board

### Active temperature regulation

These plaster boards include 3 kg/m<sup>2</sup> of heat-storing material in the shape of microcapsules containing a phase changing material (PCM). When heated to a certain point, the PCM will melt, absorbing thermal energy without any increase in temperature, while the reverse process releases the stored energy as heat, maintaining a pleasant room temperature. The heat storage capacity of a 15 mm PCM Smart Board is equivalent to that of a 90 mm concrete wall or a 120 mm brick wall.

### Examples Of Use

Reducing shifts in indoor temperature between day and night and reducing the need for air conditioning and heating.

### Similar Materials

02, 05, 40, 63, 65

### Material Data

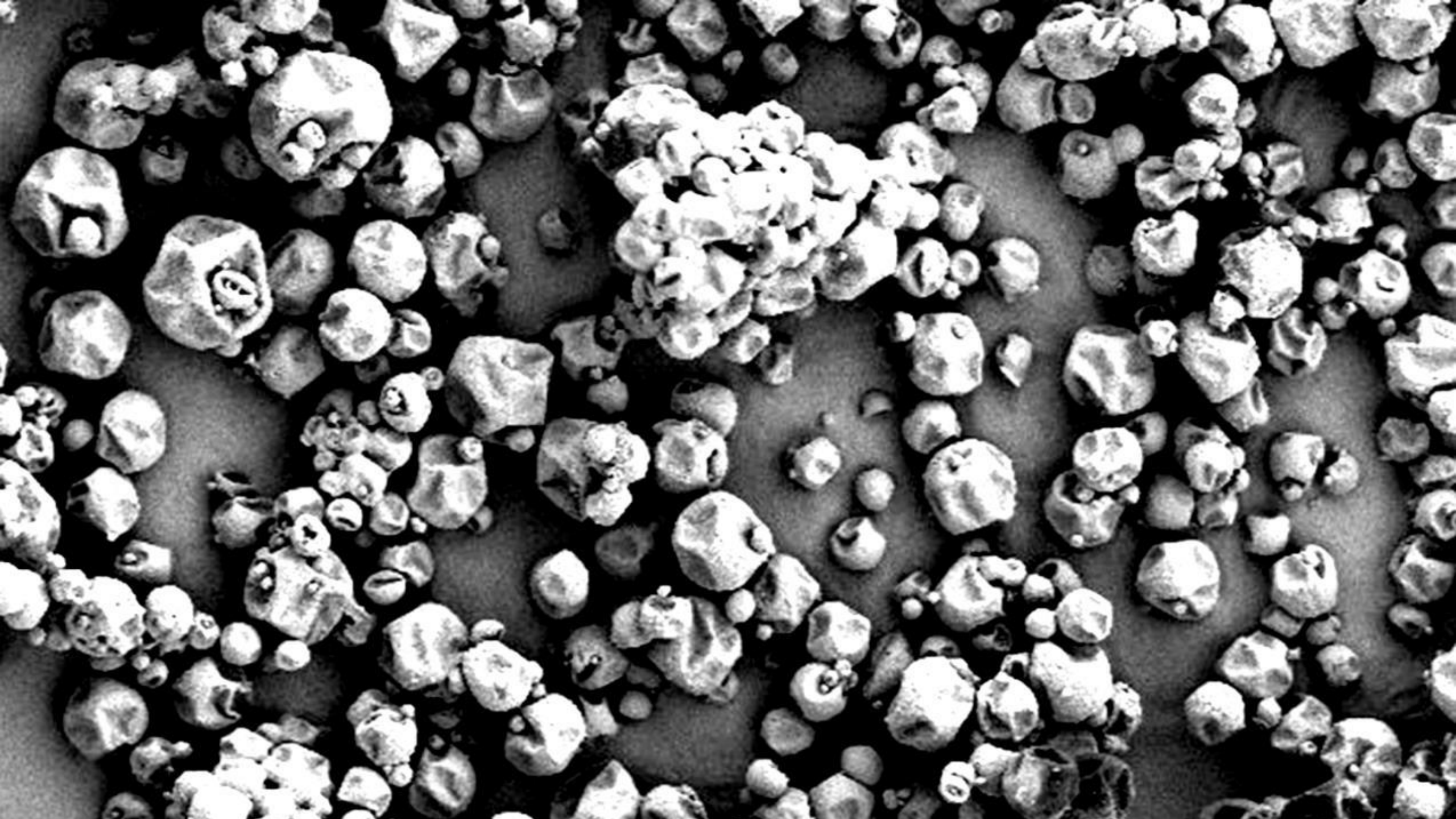
Two types available with 'switching points' temperatures at 23°C and 26°C; thickness: 15 mm; length: 2,000 mm; width: 1,250 mm.

### Manufacturer

BASF, [www.micronal.de](http://www.micronal.de)









**Green Materials**  
40-59

# 50

## Accoya

**Nontoxic high technology wood**

The production process makes fast-growing softwood into a new durable and stable product with the qualities of hardwood. Accoya is wood that has been chemically enhanced by acetylation, a process in which acetic anhydride is used to change the abundance of free hydroxyls into acetyl groups. As free hydroxyls in the wood cells enable wood to absorb water and play an important role in deterioration, water absorption and decay is avoided, which makes the wood extremely durable.

### **Examples Of Use**

Outdoor wooden structures.

### **Similar Materials**

00, 01, 14, 44, 57, 72, 86

### **Material Data**

Class 1 durability (comparable to teak), lasting at least 50 years above ground and 25 years below ground.

### **Manufacturer**

Accoya, [www.accoya.com](http://www.accoya.com)









ROYAL ARENA

A person in a dark jacket and cap walking away from the camera on the wet plaza.

Two people walking a dog on the wet plaza. One is wearing a bright red coat, and the other is in a dark jacket. A white dog is on a leash.

CRADLE TO  
CRADLE®  
I DET  
BYGGEDE  
MILJØ



EN MANUAL TIL DEN DANSKE BYGGEINDUSTRI

A close-up, top-down view of a tree trunk cross-section, showing concentric growth rings in shades of tan and brown. A prominent crack runs diagonally from the bottom left towards the center. The text 'BIOLOGICAL MATERIALS' is centered in white, bold, sans-serif font.

# BIOLOGICAL MATERIALS

WHAT IF WE CAN BUILD TOMORROW  
WITH THE WASTE OF TODAY?

















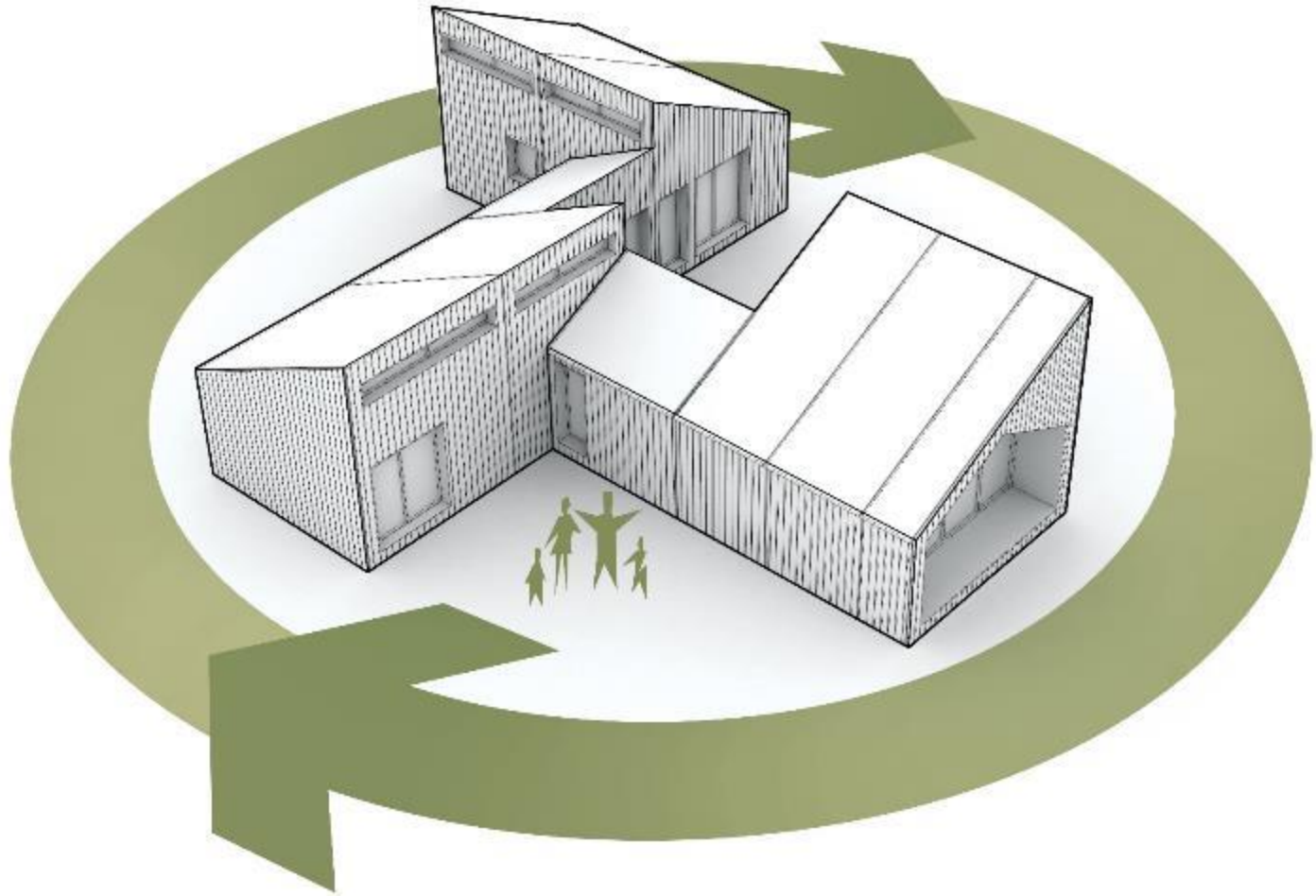


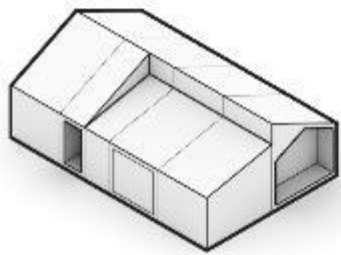




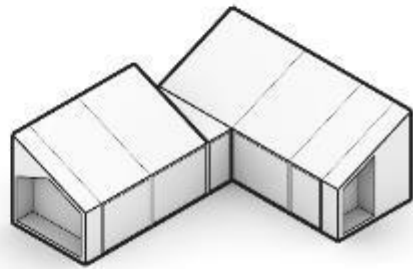




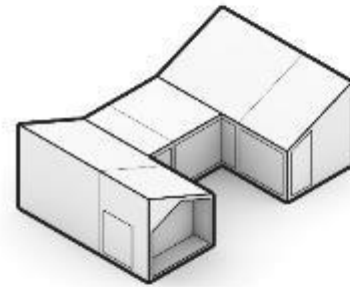




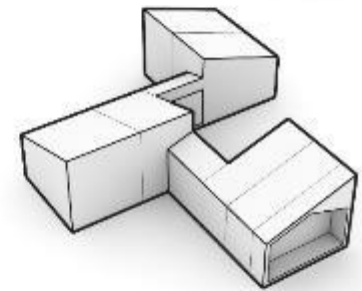
**K** | Kompakt | **120m<sup>2</sup>**



**V** | Vinkel | **109m<sup>2</sup>**

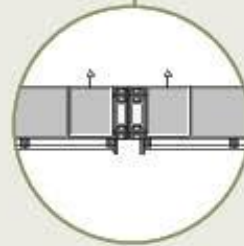
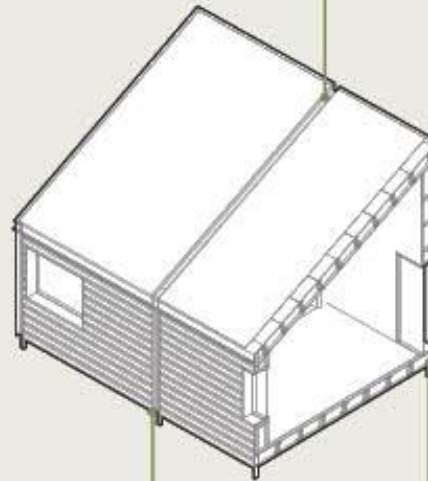
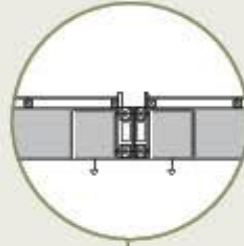


**U** | Gärdhavehus | **118m<sup>2</sup>**

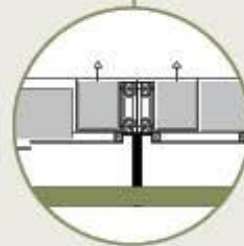


**X** | Åben Form | **137m<sup>2</sup>**

*Tagdetailje*



*Gulvdetailje*



*Fundamentdetailje*





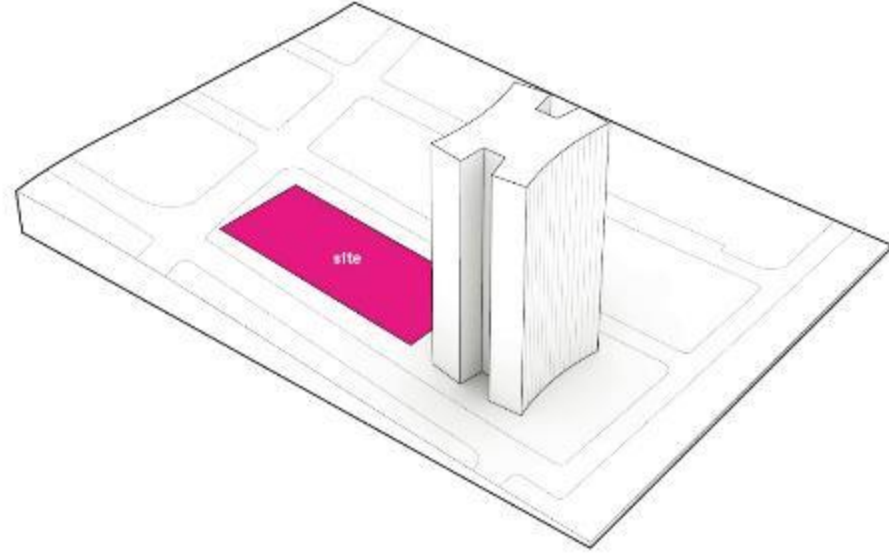


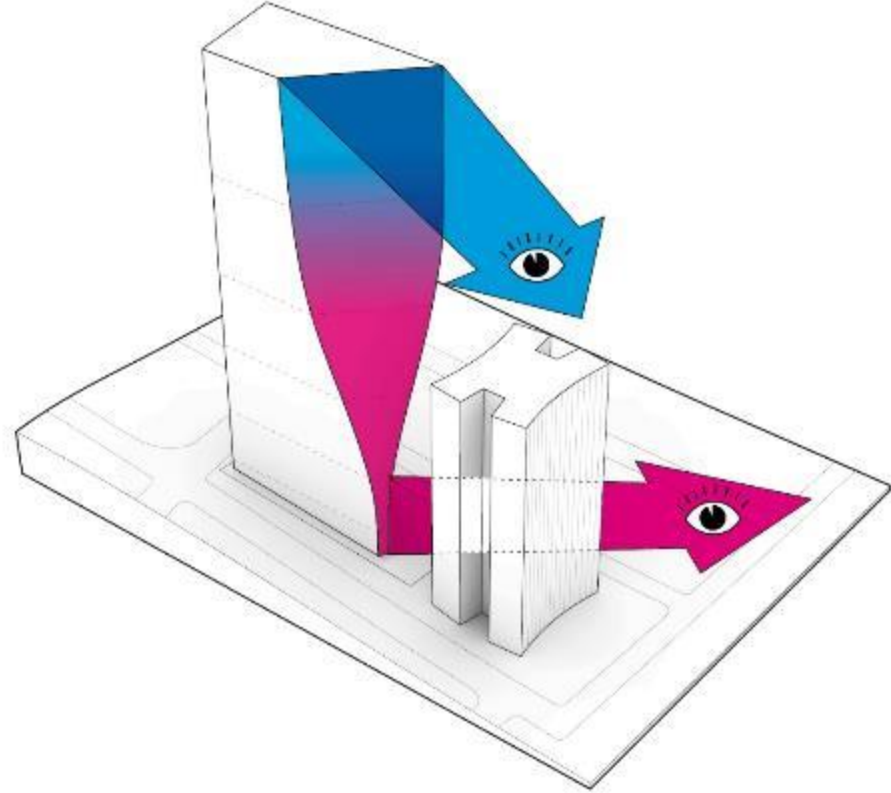
TECNICAL MATERIALS

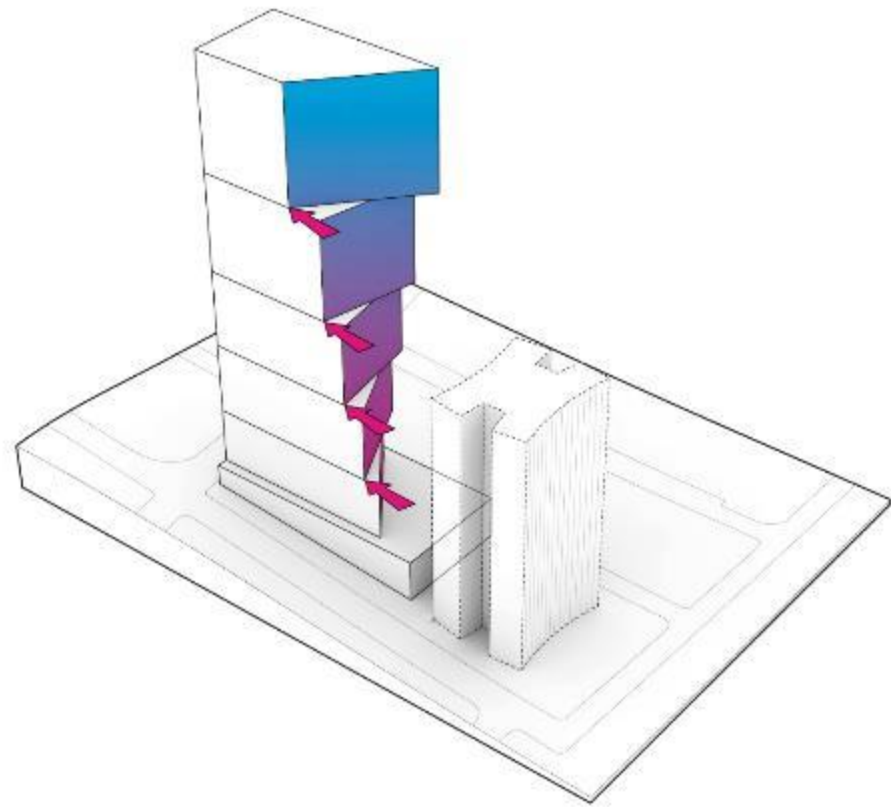
WHAT IF WE CAN CREATE CIRCULAR  
CITIES WITH URBAN MINING?

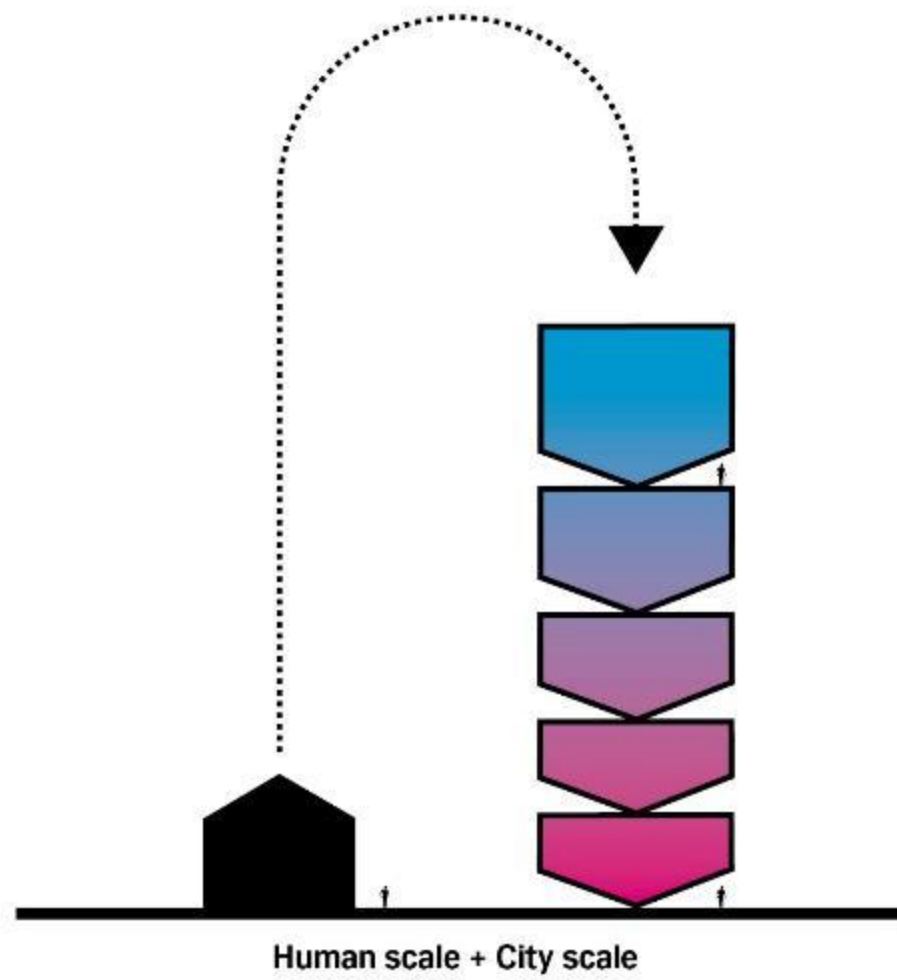








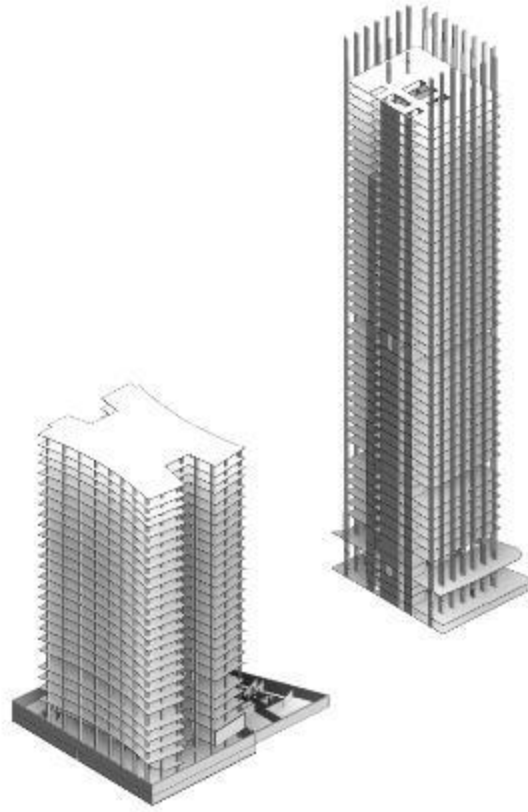
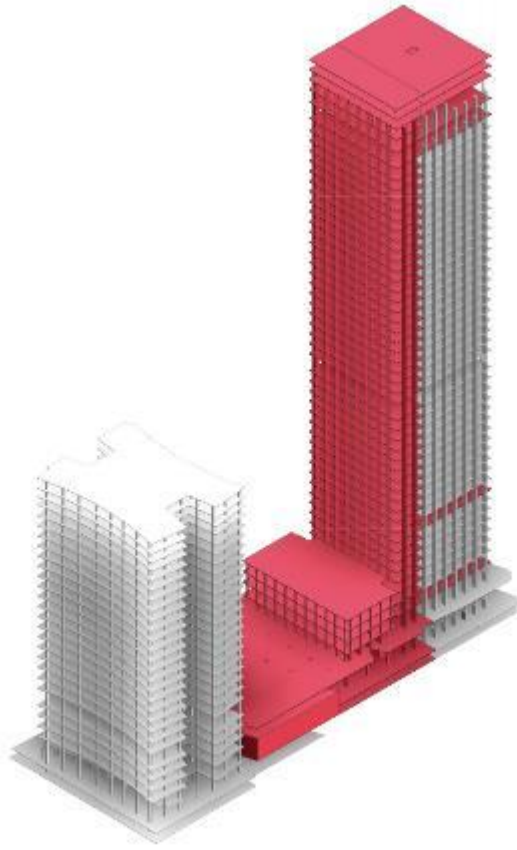












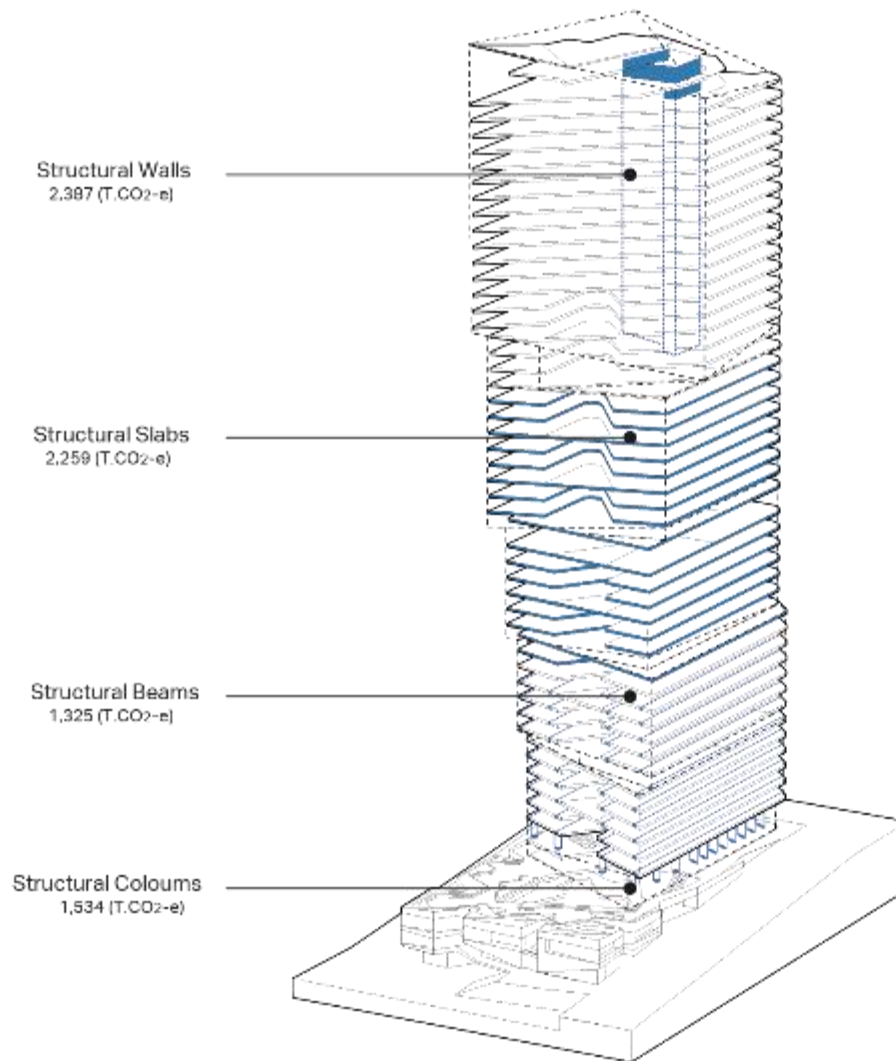
**RETAINING 98%**  
STRUCTURAL WALLS



# 7.505 Tons of CO<sub>2</sub>

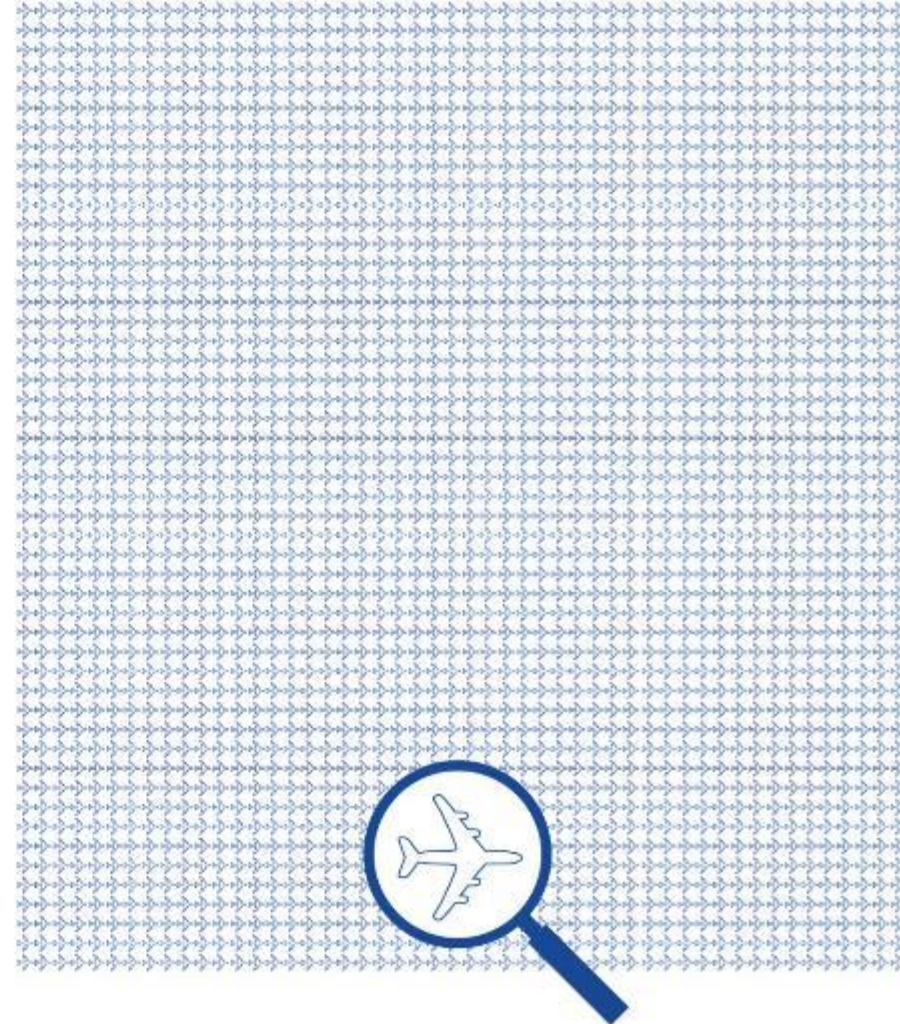
EMISSIONS SAVED

\*



\* The results are based on a published Australian data.



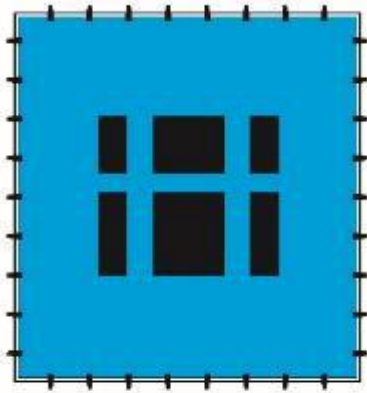


**7.505 Tons of CO<sub>2</sub>**

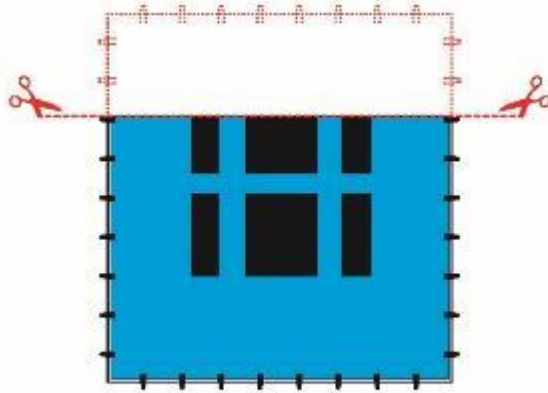
EMISSIONS SAVED

Equivalent to 2500 one-way flights  
from Sidney to Copenhagen

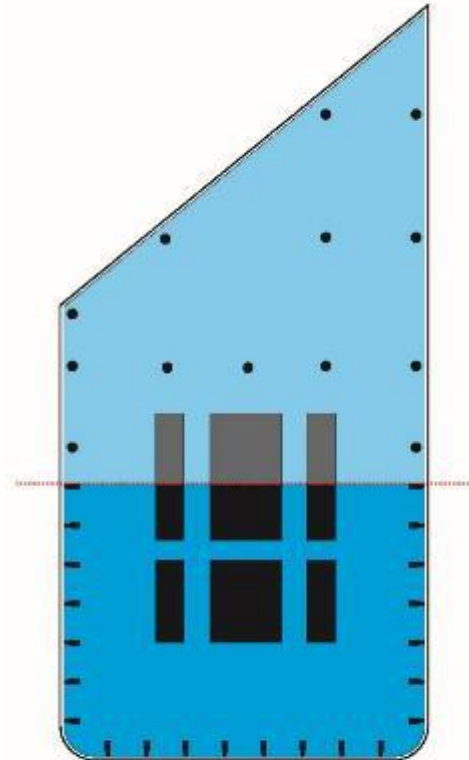
\*



Existing

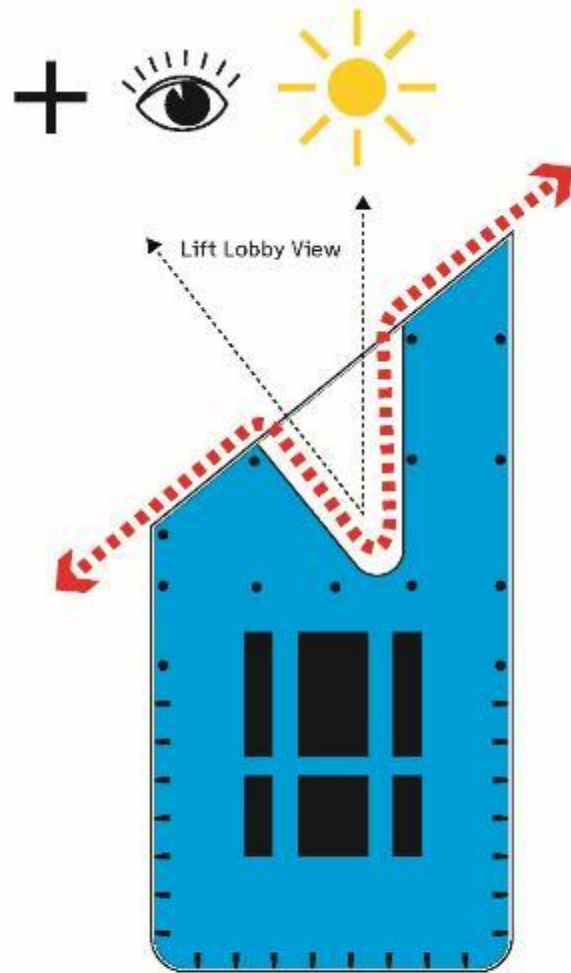


Remaining

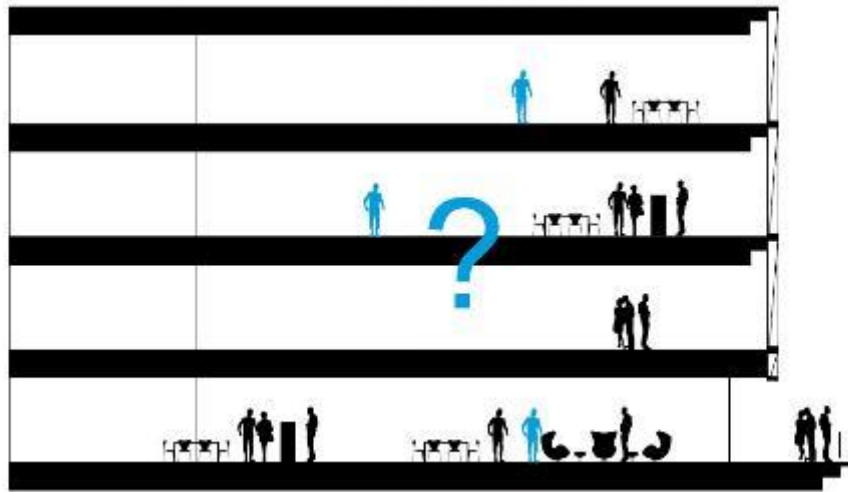


Existing / New

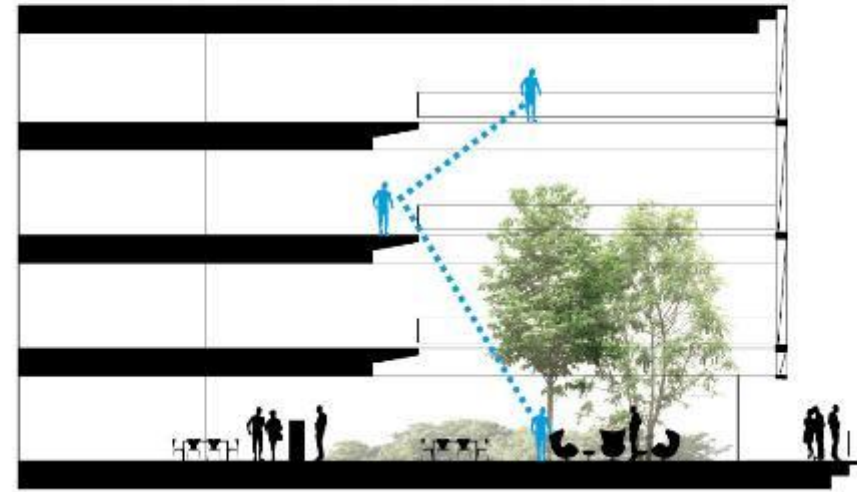
**\$130,000,000**   
MATERIAL + TIME SAVED



Increased Views / Daylighting

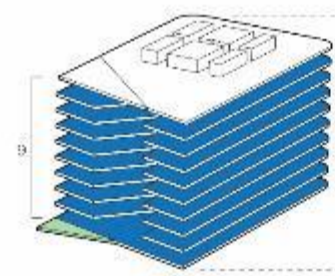


Typical High Rise

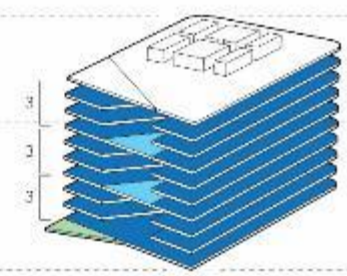


Proposal

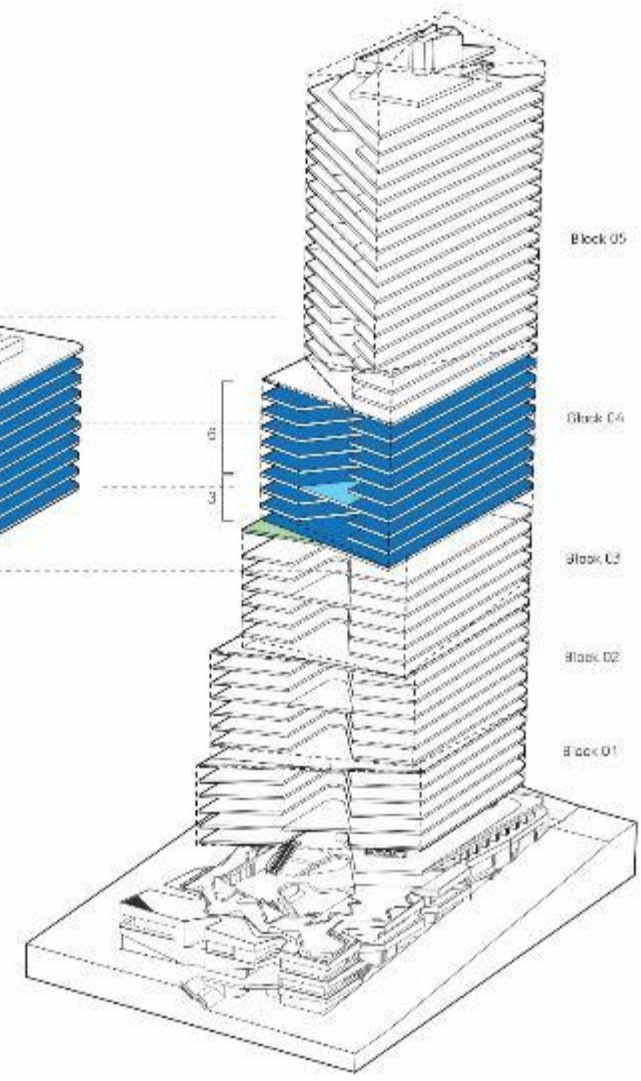
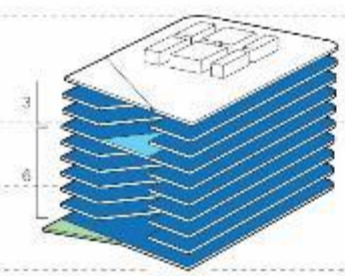
1 Atrium

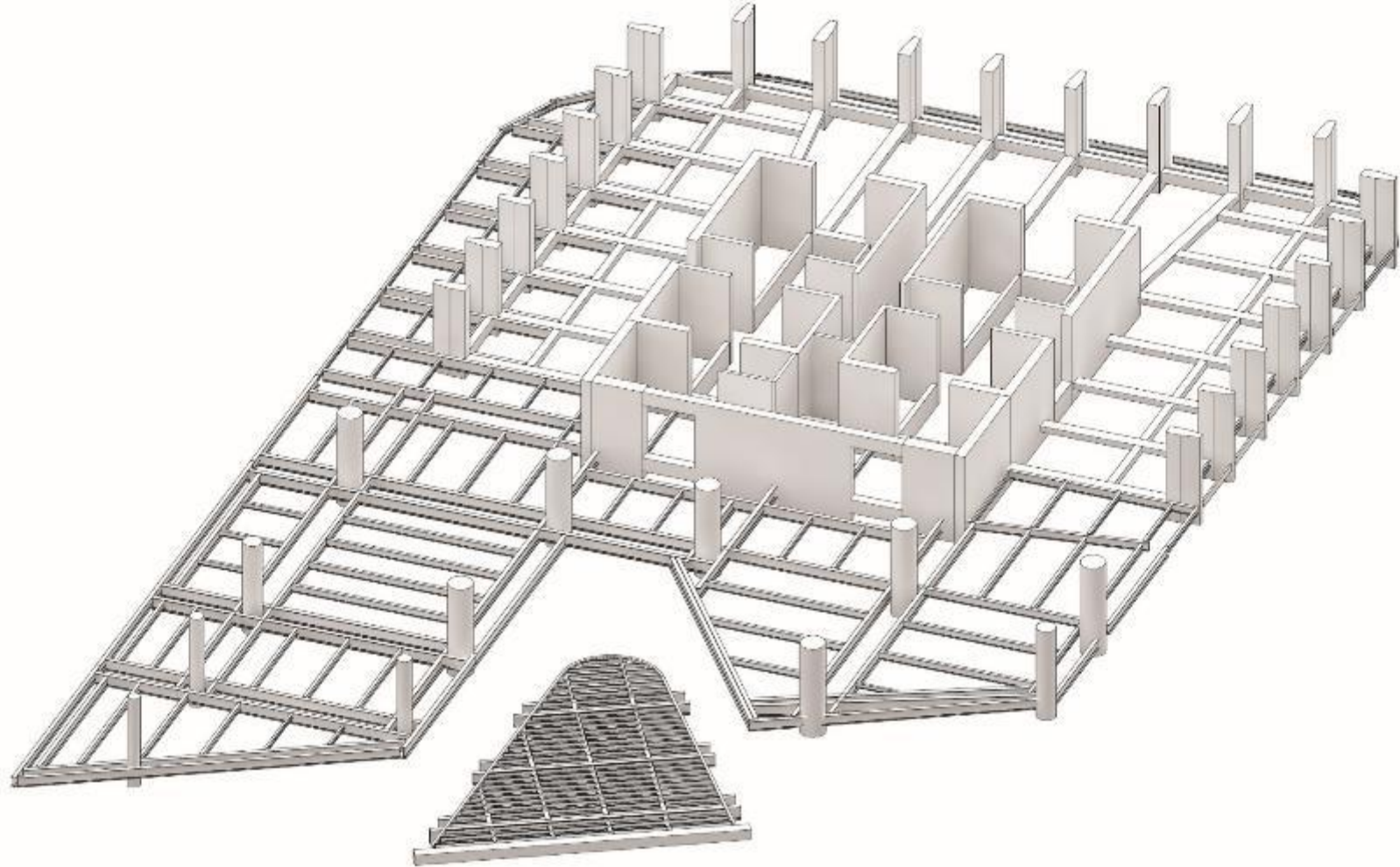


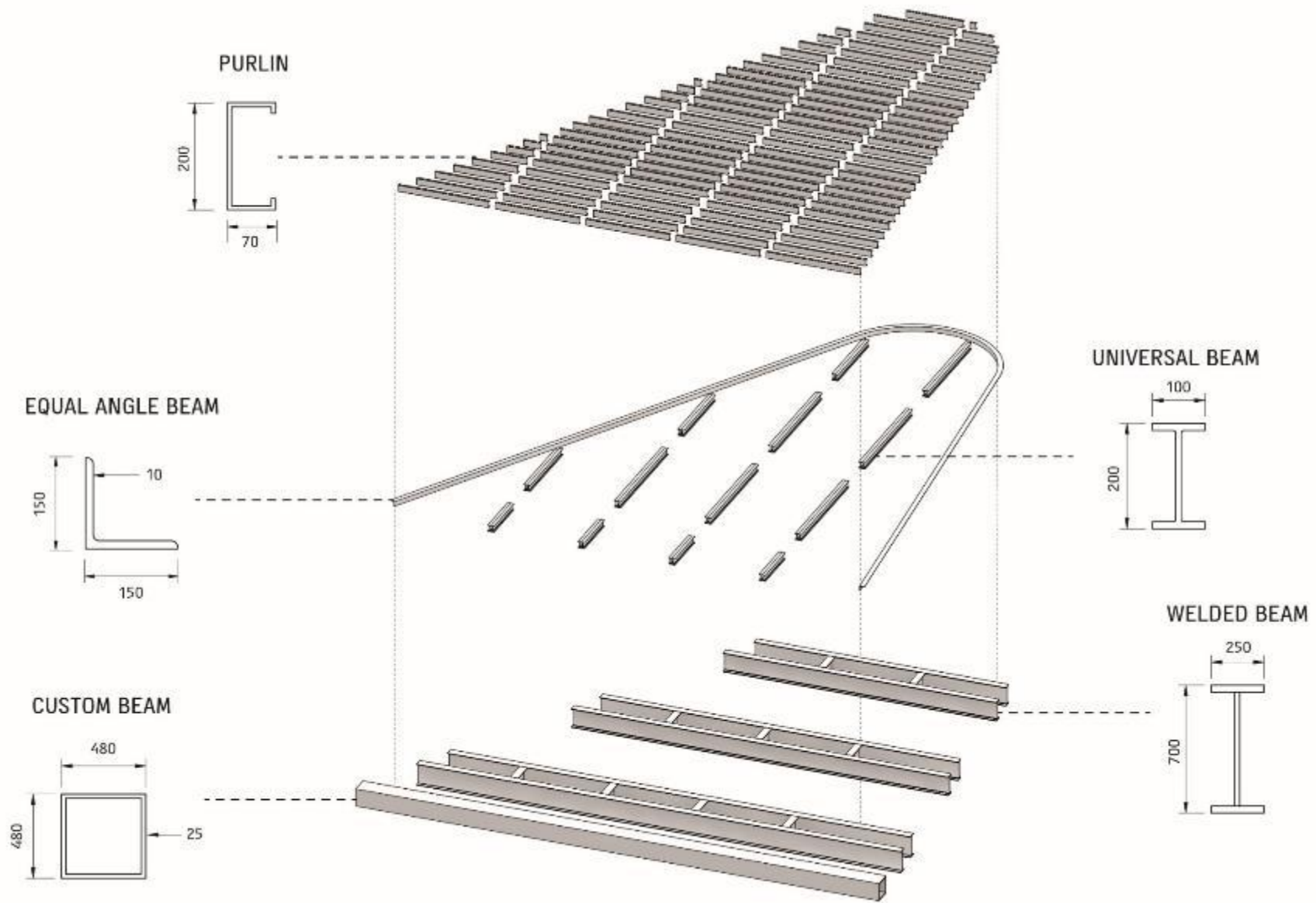
3 Atria



2 Atria

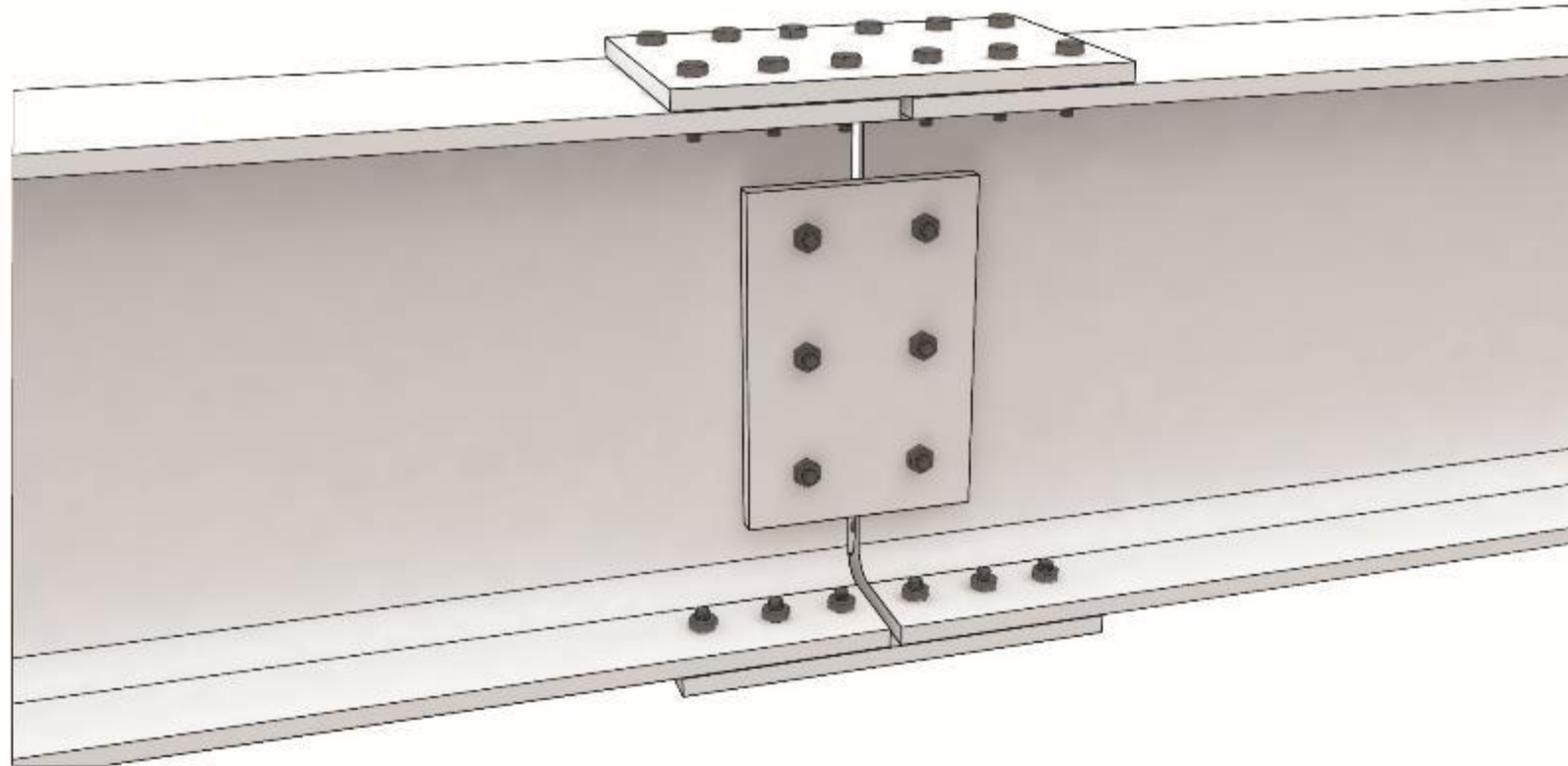


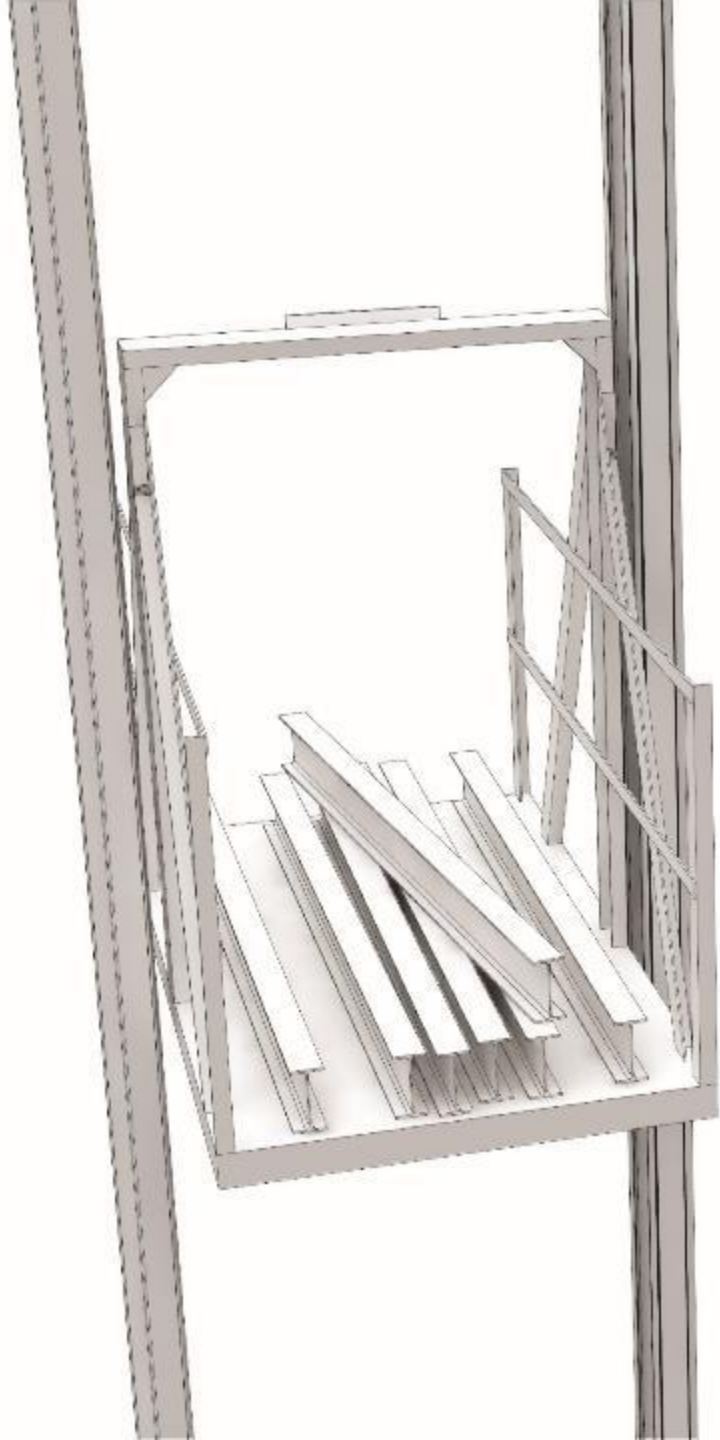




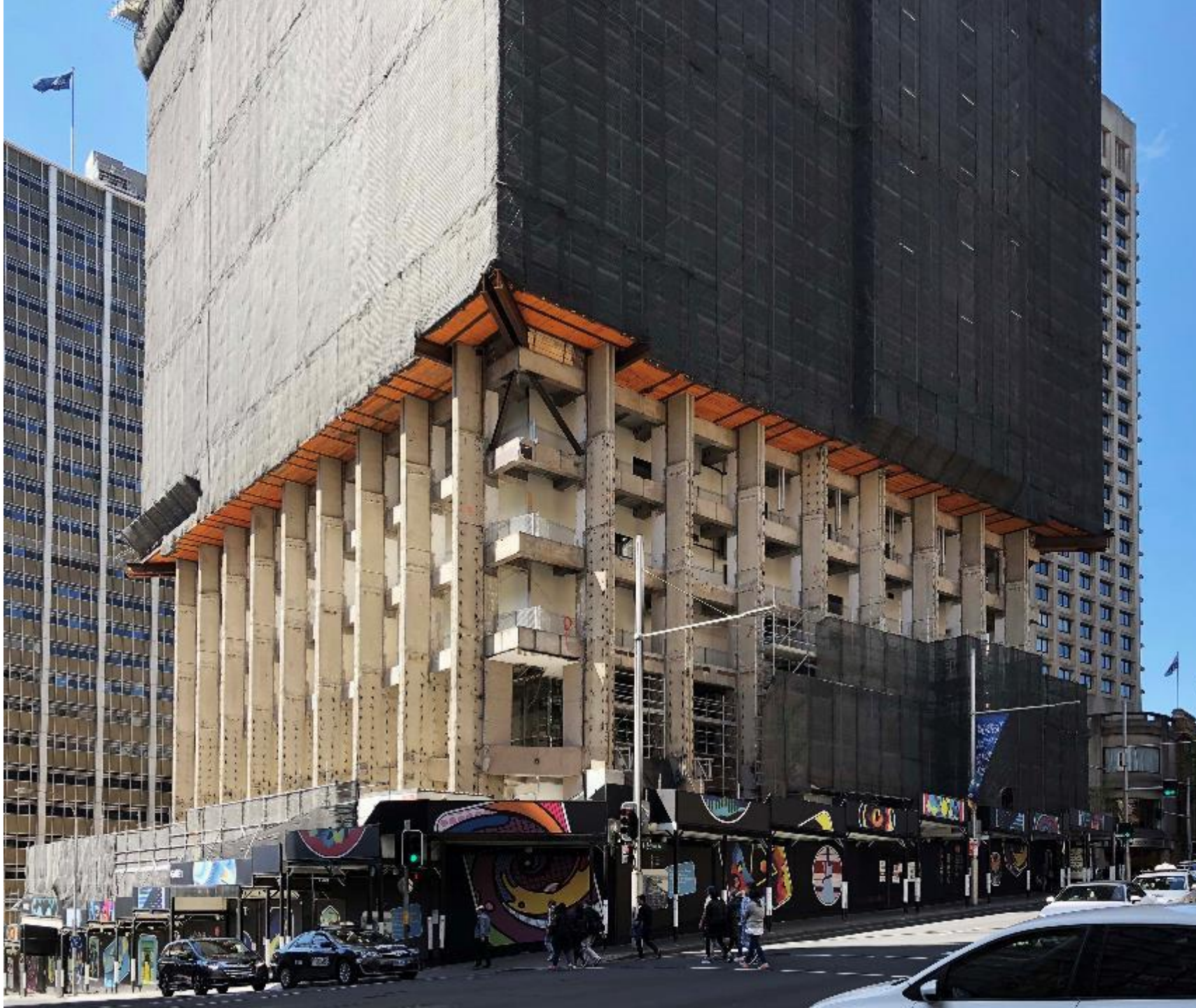


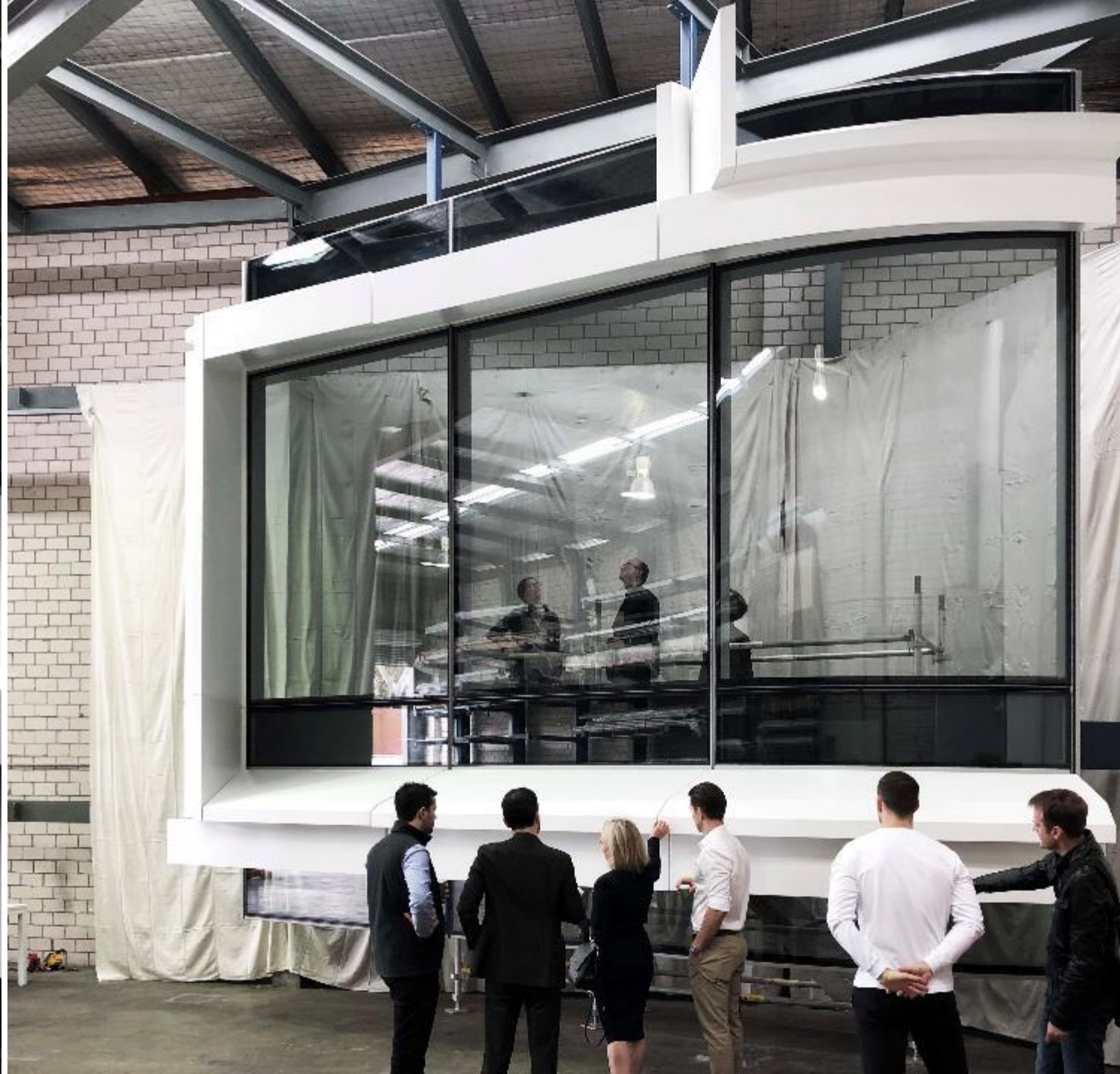
TYPICAL SPLICE DETAIL FOR ATRIUM INFILL PANEL AND DECON FLOOR









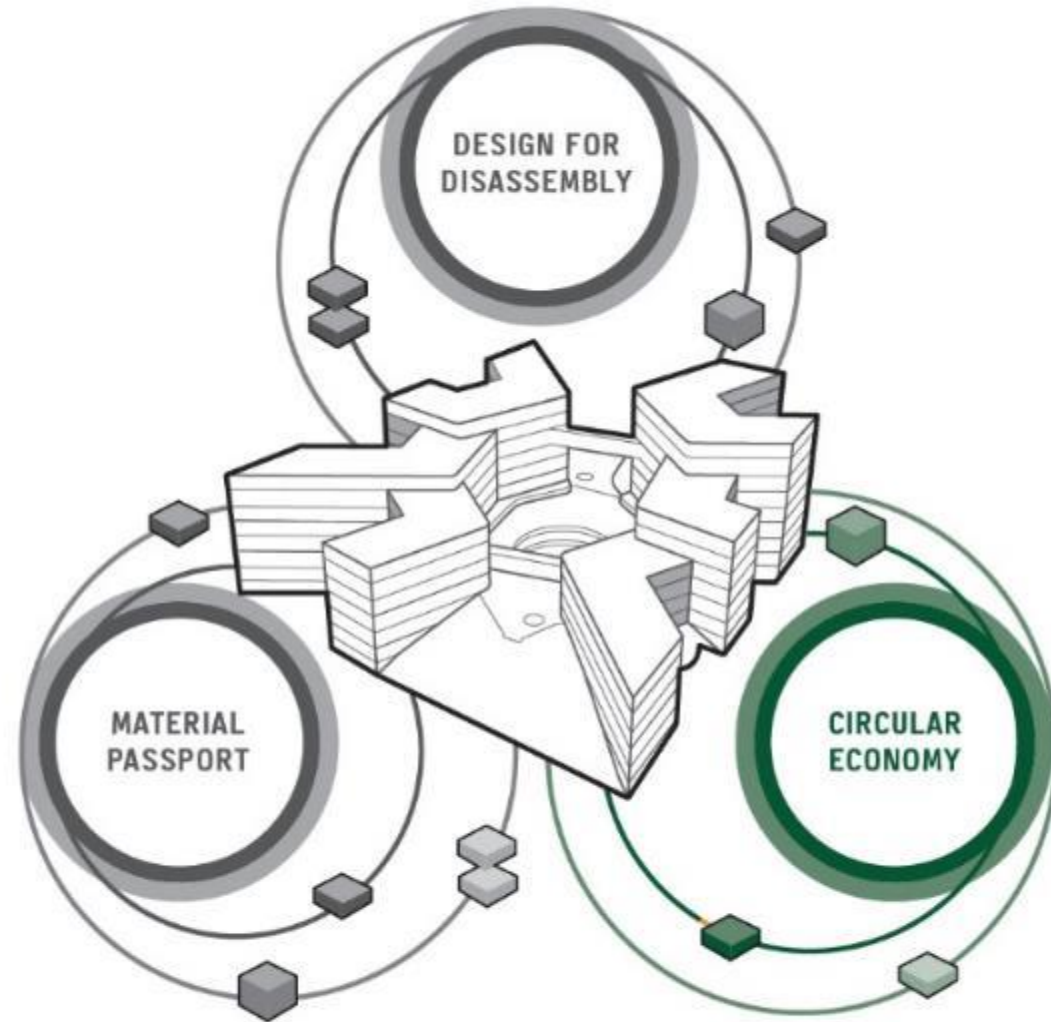


WHAT IF WE CAN TURN DEMOLITION  
INTO A GOOD BUSINESS

Building a  
Circular Future

FROM 16 MIO. COST  
TO 35 MIO. REVENUE





CIRCULAR ECONOMY



Redesigning the way we put buildings together



architects



contractors



demolitioners

In a multi disciplinary partnership



Bring ideas to life  
VIA Byggeri

constructing architects

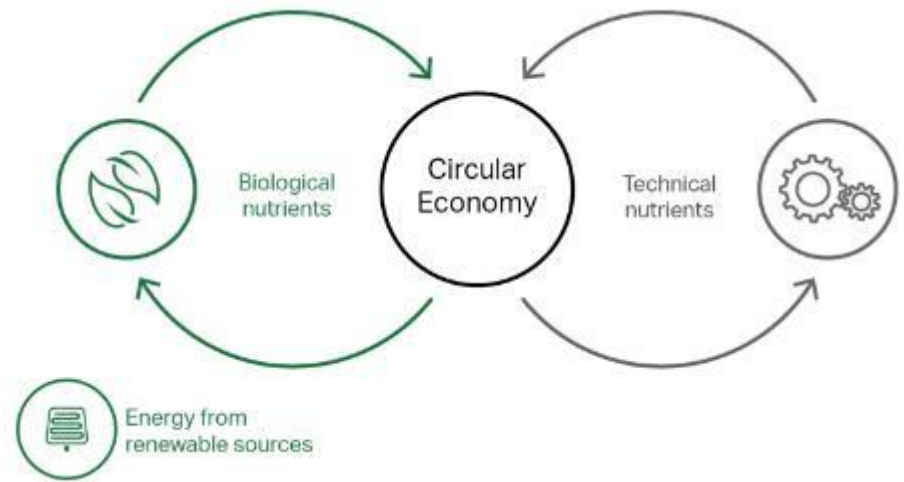
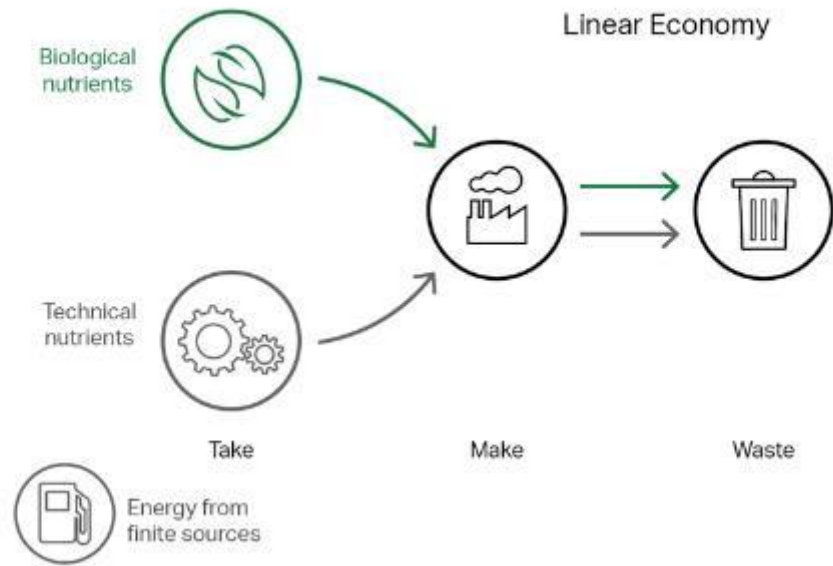
henrik•innovation

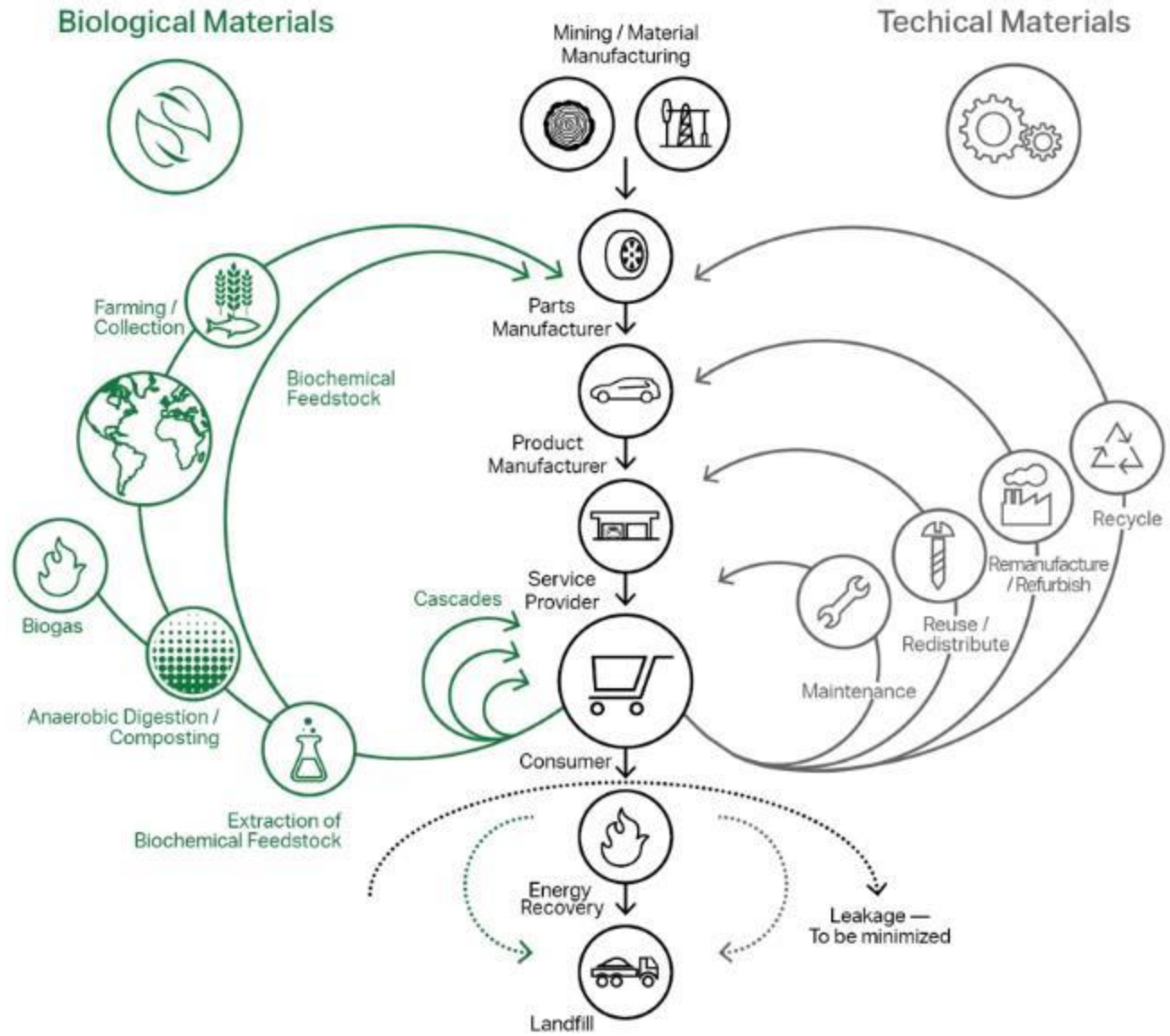
building innovation

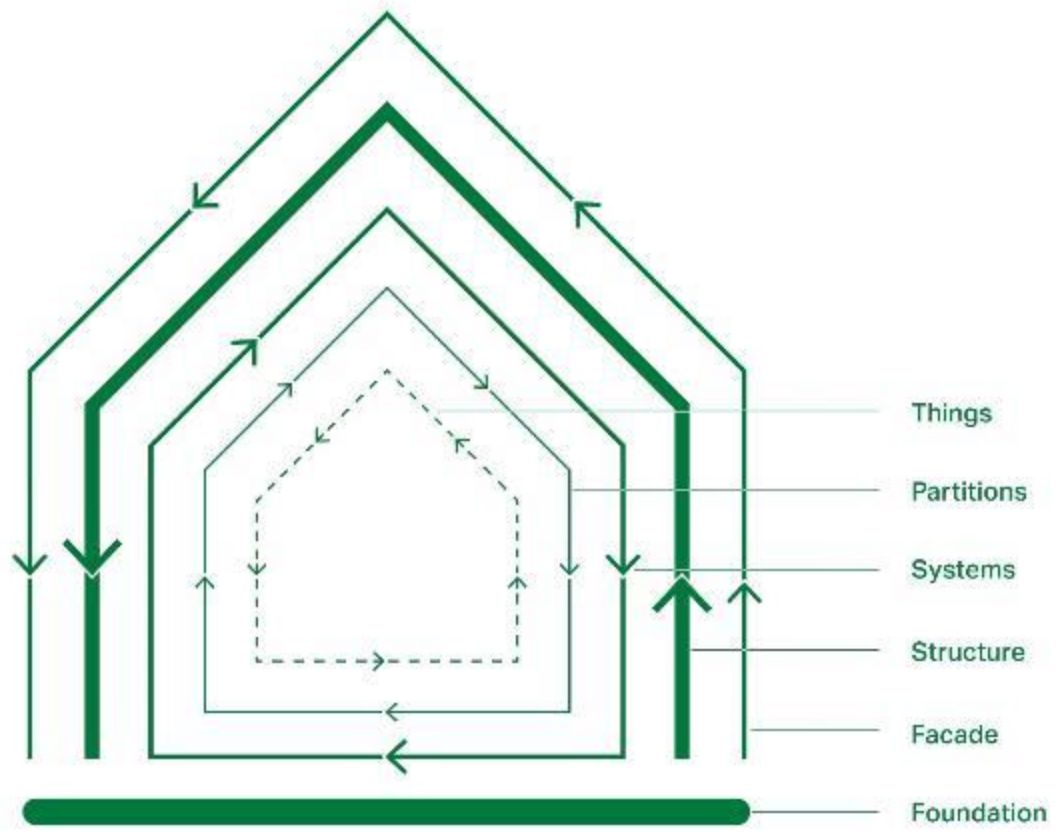


circular economy

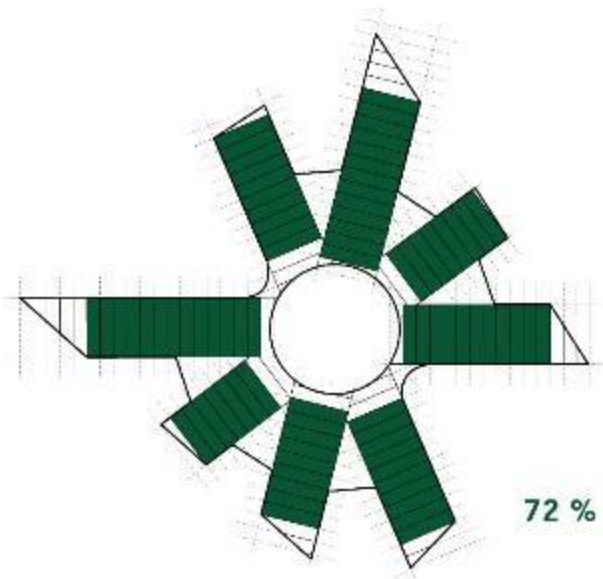




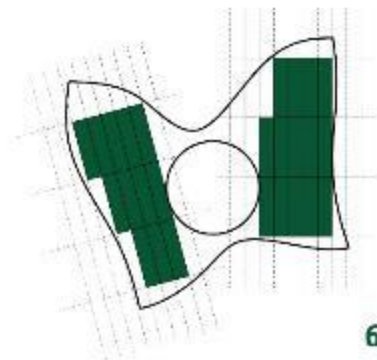




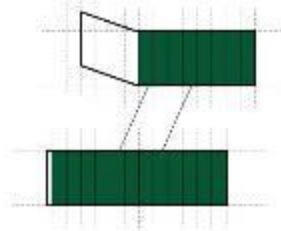




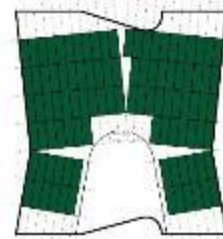
**DE FIRE STYRELSE** 3XN Architects,  
København Brygge, Denmark 2014,  
Offices, 42.000 m<sup>2</sup>



**IOC HEADQUARTERS** 3XN Architects,  
Lausanne, Switzerland 2014  
Offices, 15.000 m<sup>2</sup>

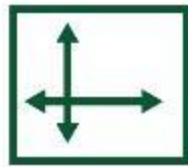


**BELLA SKY** 3XN Architects,  
Copenhagen, Denmark 2011,  
Hotel, 42.000 m<sup>2</sup>



**SAXO BANK** 3XN Architects,  
Hellerup, Denmark 2008,  
Offices, 16.000 m<sup>2</sup>

## A Building Practice with immediate and short term gains



improved  
flexibility



faster  
construction



optimized  
operation

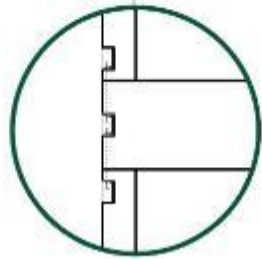
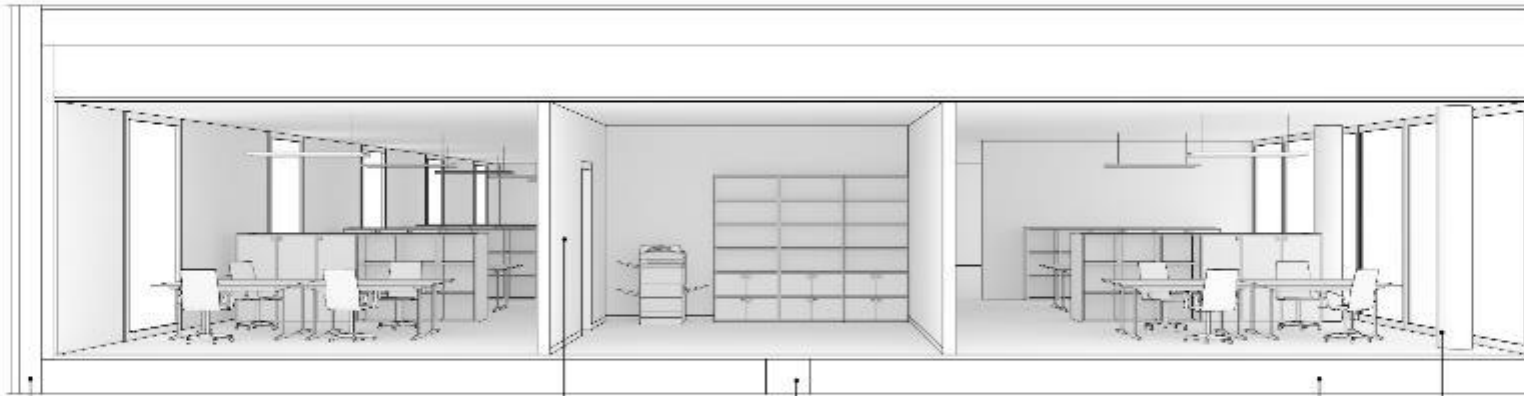
Implementation of the circular principles, not only result in long term benefits.  
Positive side effects from low hanging fruits creates a better building here and now.



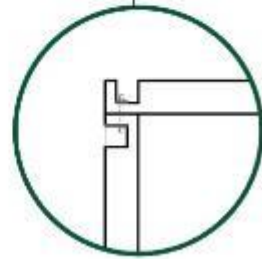
DESIGN FOR DISASSEMBLY



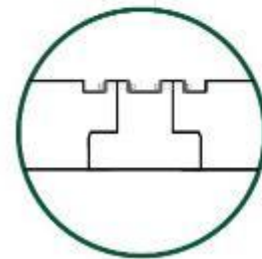




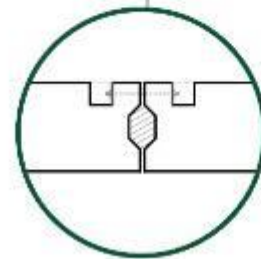
**SLAB - WALL** New separable joints using mechanical connections with nuts and bolts.



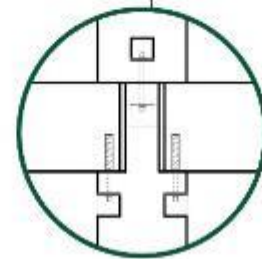
**WALL - WALL** New separable joints using mechanical connections with nuts and bolts.



**SLAB - BEAM** New separable joints using mechanical connections with nuts and bolts.



**SLAB - SLAB** New separable joints using mechanical connections with nuts and bolts and lime mortar.



**COLUMN - SLAB** New separable joints using mechanical connections with nuts and bolts and lime mortar.

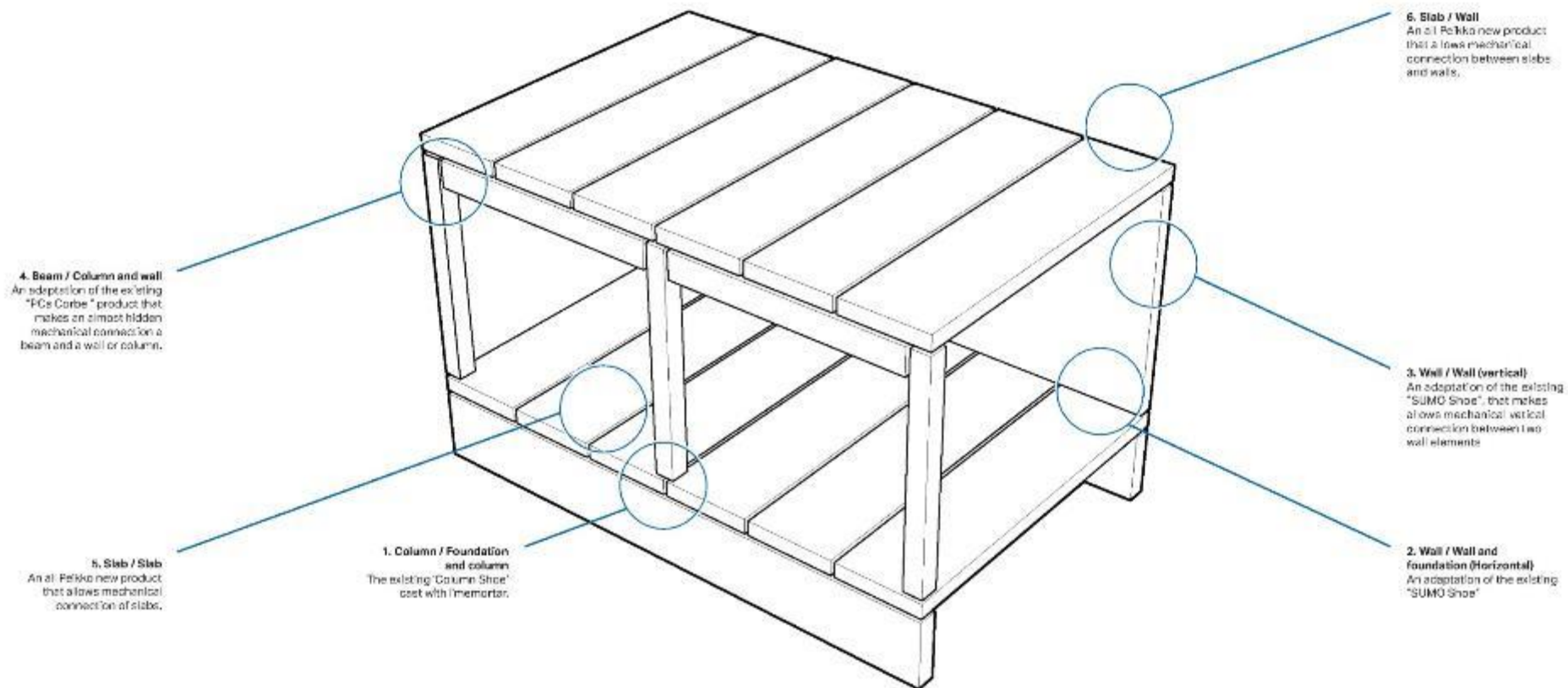






## A circular building system

— For the future Peikko



**4. Beam / Column and wall**  
An adaptation of the existing "FCs Corbe" product that makes an almost hidden mechanical connection a beam and a wall or column.

**5. Slab / Slab**  
An all-Peikko new product that allows mechanical connection of slabs.

**1. Column / Foundation and column**  
The existing "Column Shoe" cast with lime mortar.

**6. Slab / Wall**  
An all-Peikko new product that allows mechanical connection between slabs and walls.

**3. Wall / Wall (vertical)**  
An adaptation of the existing "SUMO Shoe", that makes allows mechanical vertical connection between two wall elements.

**2. Wall / Wall and foundation (Horizontal)**  
An adaptation of the existing "SUMO Shoe".

### Mapping of new and existing solutions

A numbered order of solutions in the Peikko product portfolio that has a circular potential. The lower the closer they are to being completely circular.

### General considerations

A general consideration for the solutions is that the grout is cast with lime mortar, which solves issues regarding fire, sound, corrosion and prevent people from accessing the joint. The mortar however won't transfer any forces.

Instead of using lime mortar in the Peikko brackets, a special "cover cap" could also be developed to protect the joints. This could be made from e.g. fibre concrete, etc.

## Workshop I

— Peikko Group, Lahti, Finland, May 25<sup>th</sup> 2017

### Aim

The aim of the workshop was to develop concepts of circular economy within Peikko, specifically in relation to existing company culture, strategy, and products.

### Participants

#### *Peikko Group*

Topi Paananen – CEO Peikko Group  
Jonas Hog – Director, Peikko Danmark  
Suvi Kauppila, Project Manager, Development Projects  
Petri Suur-Askola, Business Director, Concrete Connections  
Slavomir Matiascko, Product Manager, Precast frames  
Janne Myllynen, Sourcing Director  
Jorma Kinnunen, Senior Manager, R&D  
Gregor Schabrun, Area Director Mediterranean

#### *GXN Innovation*

Kasper Guldager Jensen, Senior Partner 3XN, Director GXN  
Jeppe Kongstad Hjort, Architect MAA  
Casper Østergaard Christensen, Architect MAA,  
Kåre Stokholm Poulsen, Head of Innovation GXN



## Workshop II

— 3XN Architects and GXN Innovation, Copenhagen,  
Denmark June 8<sup>th</sup> 2017

### Aim

The aim of the workshop was to develop ideas and concepts for a future Peikko Circular Building System as well as a vision and roadmap for Peikko in the circular economy.

### Participants

#### *Peikko Group*

Jonas Hog – Director, Peikko Danmark  
Suvi Kauppila, Project Manager, Development Projects  
Petri Suur-Askola, Business Director, Concrete Connections  
Slavomir Matiasko, Product Manager, Precast frames  
Janne Myllynen, Sourcing Director  
Jorma Kinnunen, Senior Manager, R&D  
Gregor Schabrun, Area Director Mediterranean

#### *GXN Innovation*

Kasper Guldager Jensen, Senior Partner 3XN, Director GXN  
Jeppe Kongstad Hjort, Architect MAA  
Casper Østergaard Christensen, Architect MAA,  
Lasse Lind, Head of Consulting GXN



## Circular connections

— Experiment with steel joints cast with lime mortar



### Experiment with lime mortar

Since the book Building a Circular Future, GXN has worked with theory that the Peikko brackets can be casted out with lime mortar and then removed it again by hydro-blasting. The mortar only needs to protect the connection from fire and corrosion

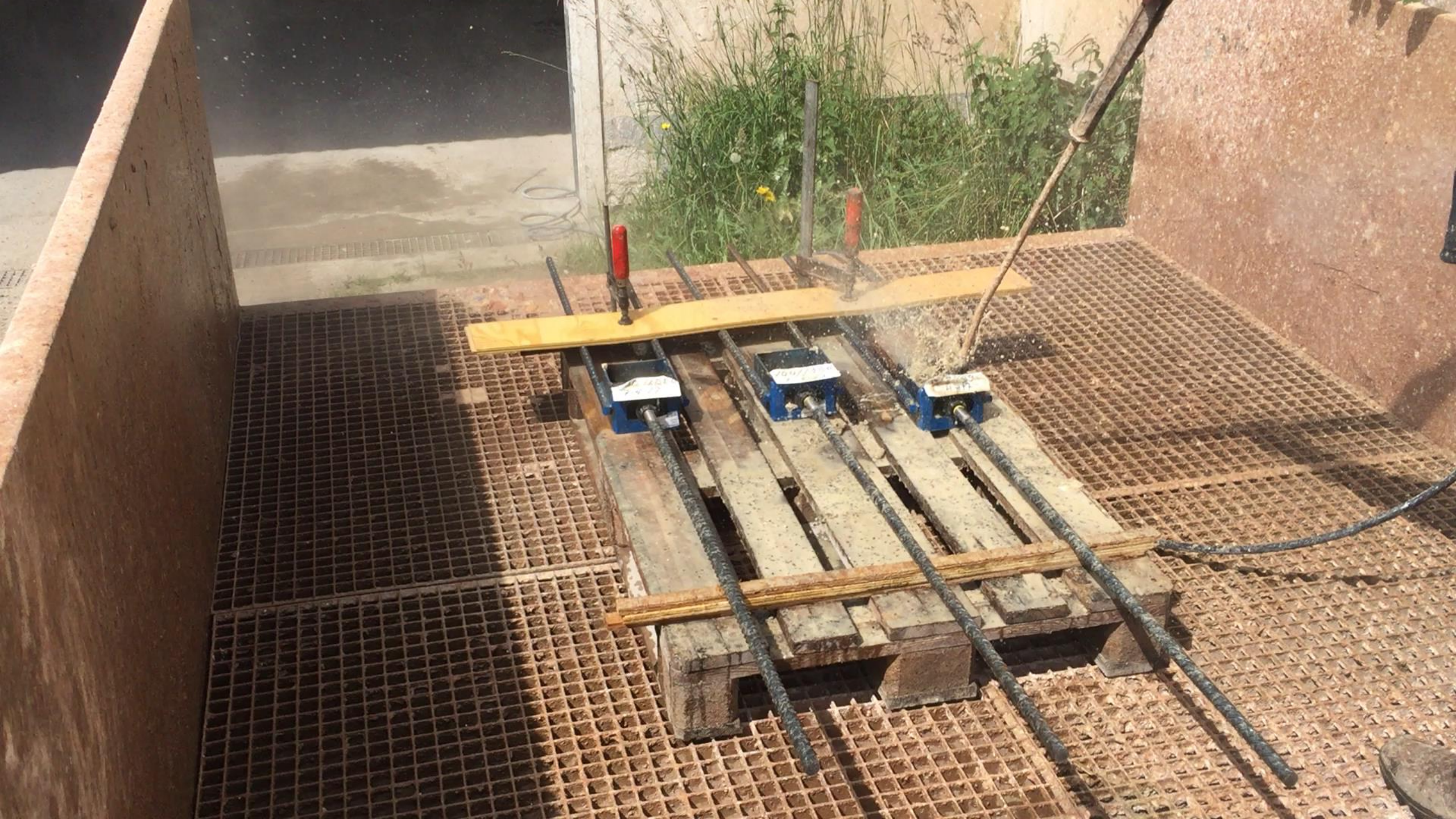
and therefore needs transfer any loads. During the Circle House project we have tested out the theory in practice in collaboration with Peikko and Kalk.



Three Peikko SUMO Shoes were casted with different strengths of mortar, and were allowed to cure for two months. During drying, no cracks occurred, thus maintaining the technical properties.

Blasting the lime mortar with a high pressure cleaner, exceeded all expectations. It was possible to remove the weakest of the three mortars in just 10 seconds. It is not only a very simple, but also very fast process.





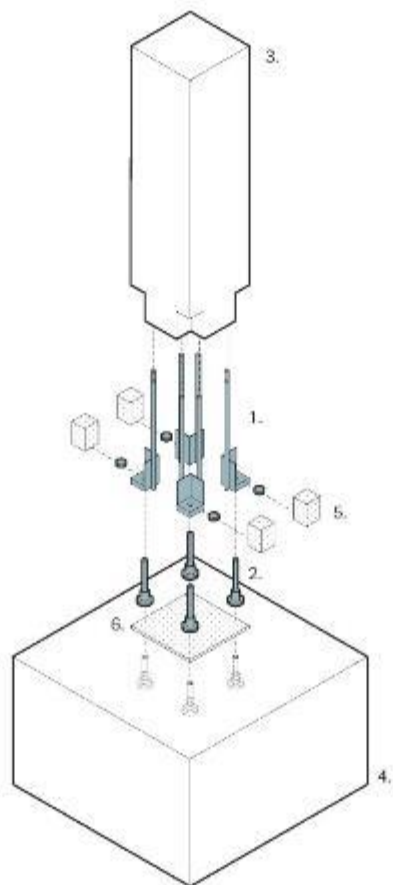
10/1000  
7-4-17

100/1500  
7-4-17

100/2000  
7-4-17

## Circular connections

### — 1. Column / Foundation and column



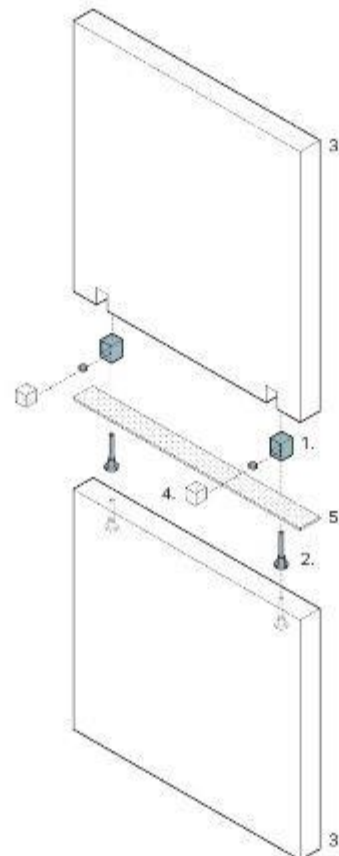
#### 1. Column / Foundation and column

The current 'Column Shoe' product is very close to being circular and needs only minor adaptation. The protective casting around the connection needs to be easily removable, e.g. a lime mortar or cover cap.

1. Peikko column shoe.
2. Cast-in threaded rod.
3. Pre-cast concrete column.
4. Concrete foundation.
5. Lime mortar casting or cover cap.
6. Lime mortar grouting.

## Circular connections

### — 2. Wall / Wall and foundation (Horizontal)



#### 2. Wall / Wall and foundation (Horizontal)

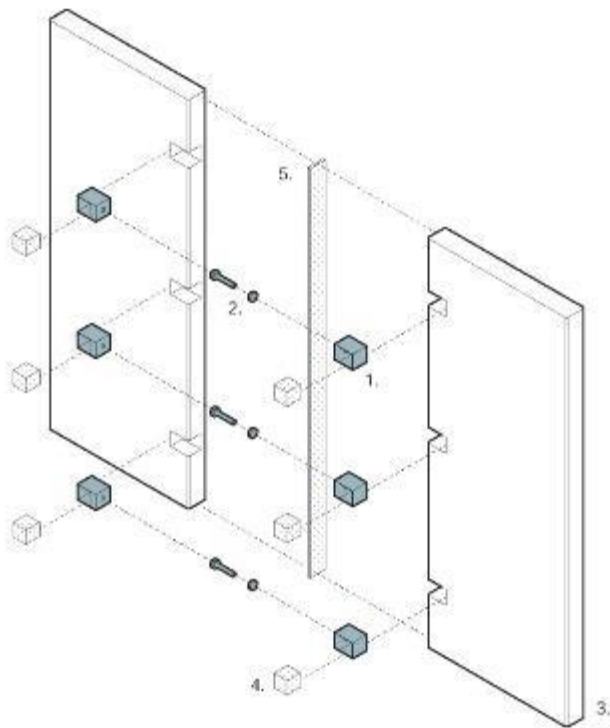
The current 'SUMO Shoe' product is very close to being circular and needs only minor adaptation. The protective casting inside the brackets needs to be easily removable, e.g. a lime mortar (like shown in the experiment) or cover cap.

1. Peikko SUMO Shoe.
2. Cast-in threaded rod.
3. Pre-cast concrete wall element.
4. Lime mortar casting or cover cap.
5. Lime mortar grouting.



## Circular connections

### — 3. Wall / Wall (Vertical)



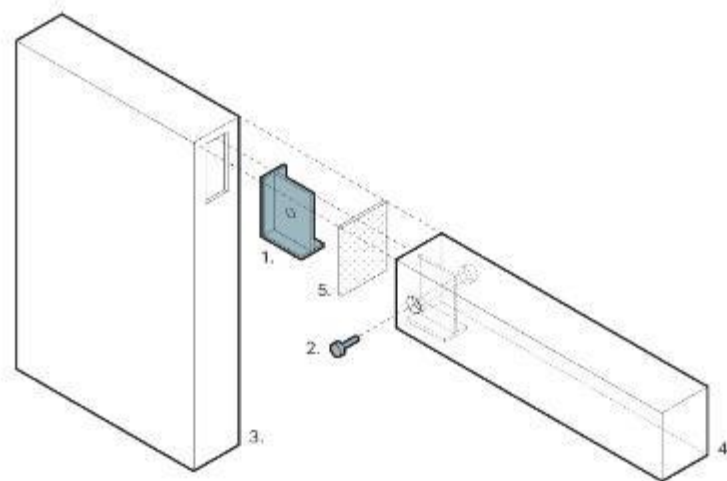
#### 3. Wall / Wall (vertical)

An adaptation of the current "SUMO Shoe", that makes allows mechanical vertical connection between two wall elements. The casting between the elements and inside the brackets needs to be removable, e.g. a lime mortar. To better transfer forces the "SUMO Shoes" can be placed diagonally in the element.

1. Modified Peikko SUMO Shoe.
2. Bolt for connecting.
3. Pre-cast concrete wall element.
4. Lime mortar casting or cover cap.
5. Lime mortar grouting.

## Circular connections

### — 4. Beam / Column and wall



#### 4. Beam / Column and wall

An adaptation of the existing "PCs Corbel" product that makes an almost hidden mechanical connection a beam and a wall or column. The bracket is cast or mounted to the wall or column. The beam has a slit that covers and protects the steel.

1. Modified Peikko PCs Corbel.
2. Bolt for connecting.
3. Pre-cast concrete wall element.
4. Pre-cast concrete beam.
5. Lime mortar grouting.



**'Being in front is not  
ambitious enough'**

— **Topi Paananen**  
CEO, Peikko Group



# Circle House / Demonstrator

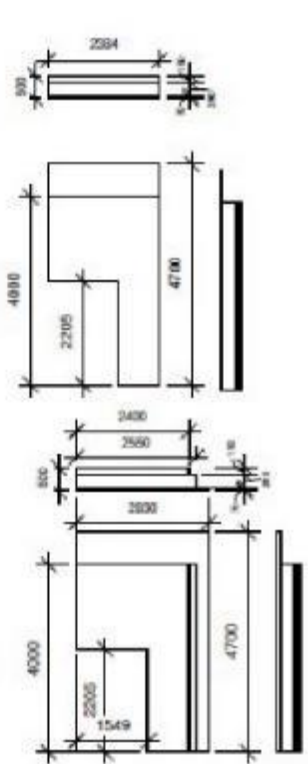
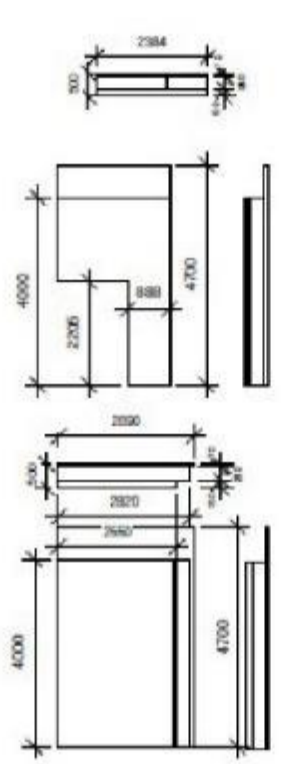
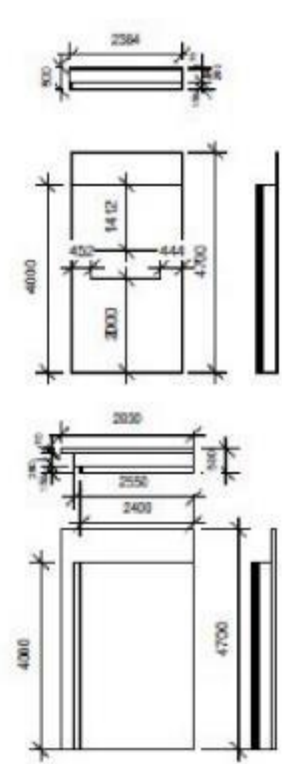
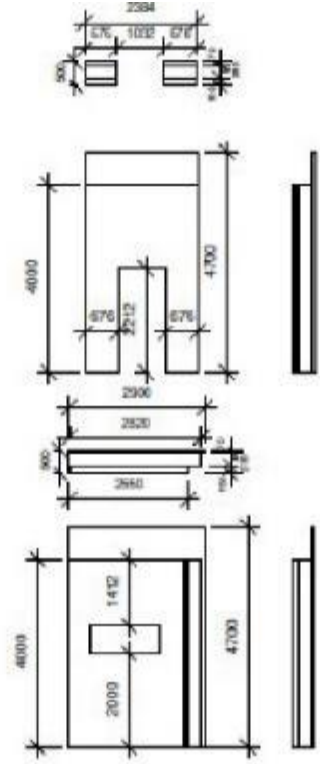
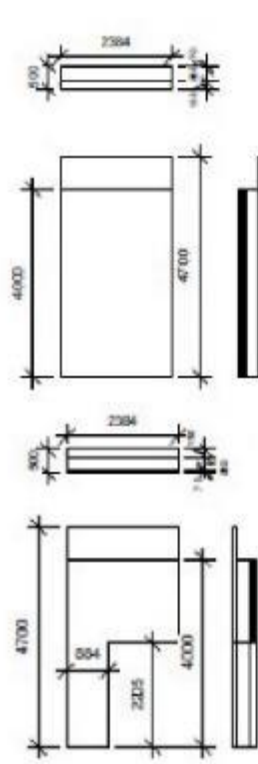
**Exposition / Exterior**













+



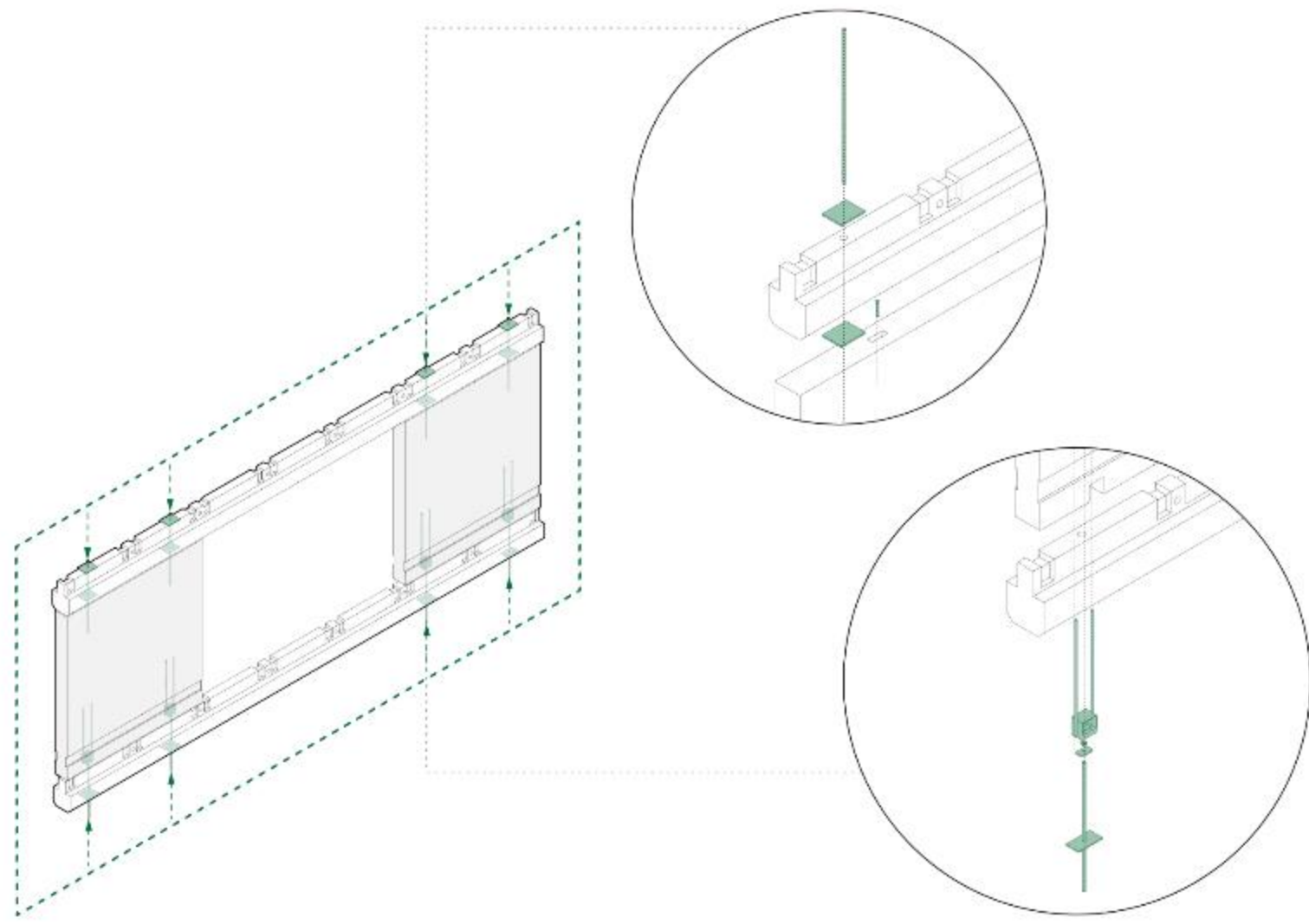
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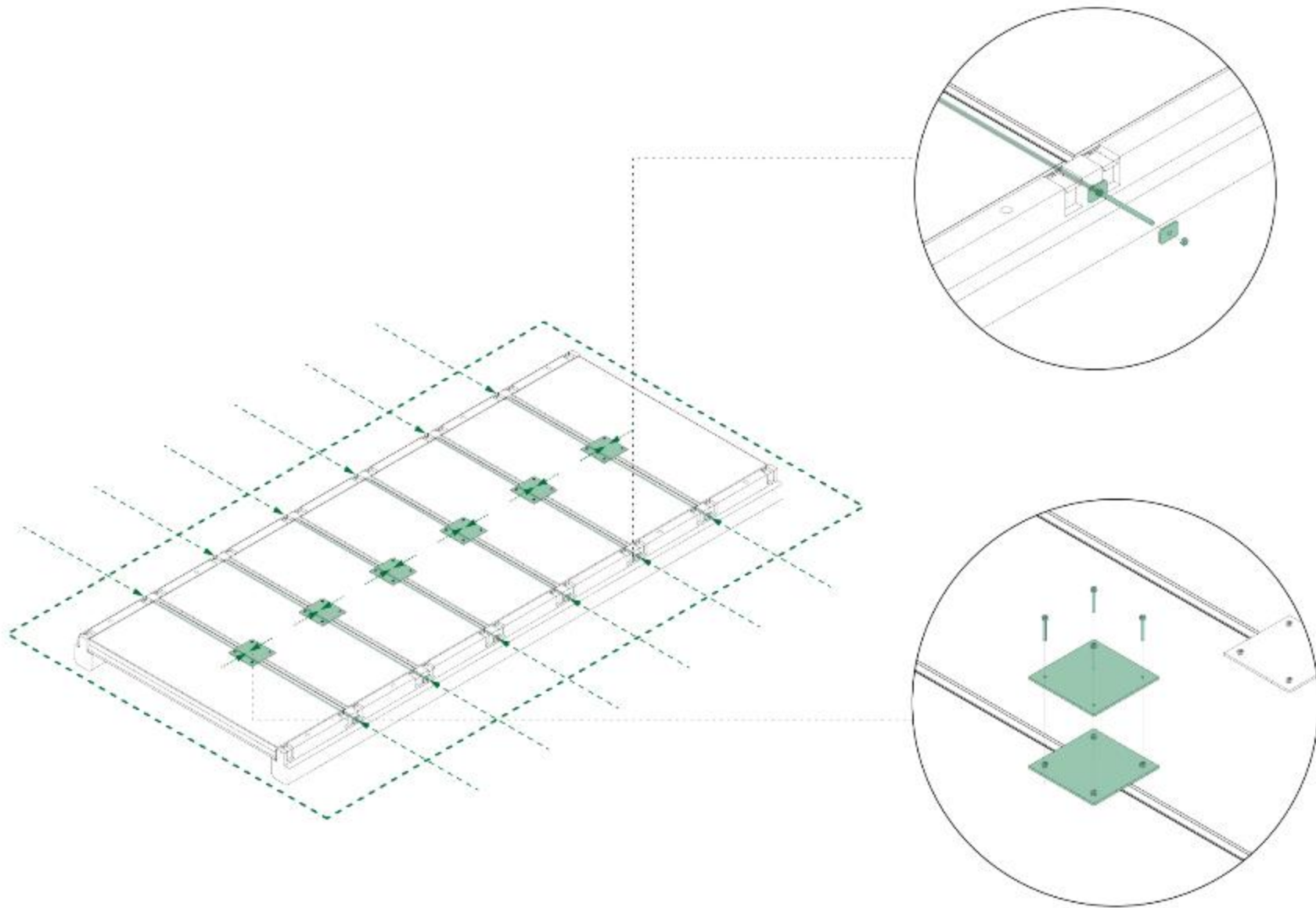


Wall

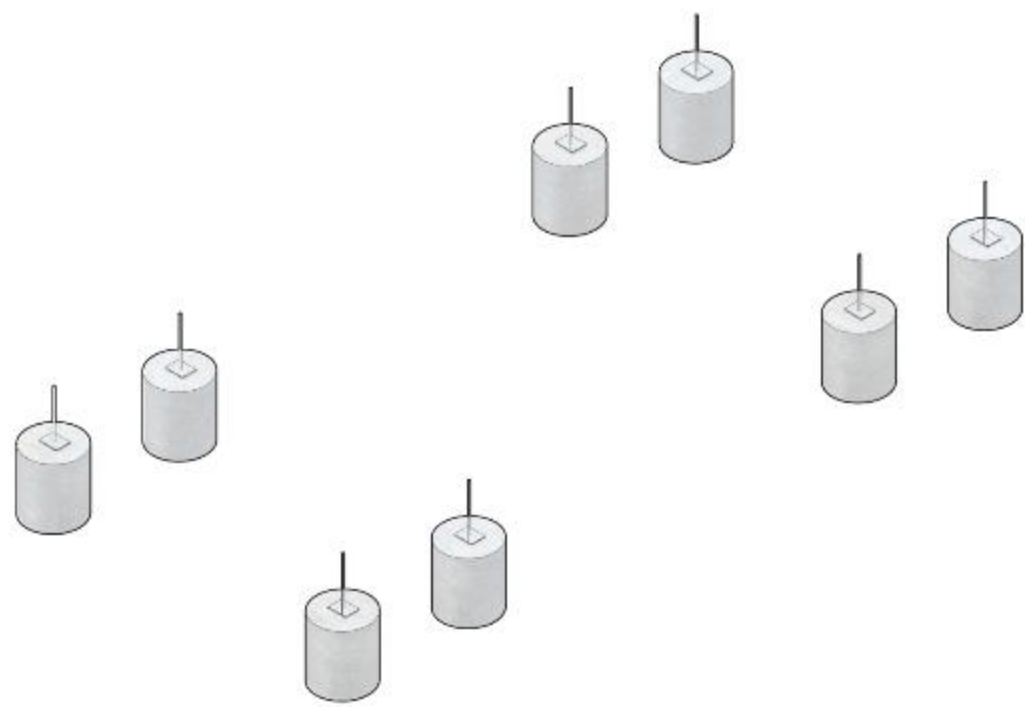
Beam

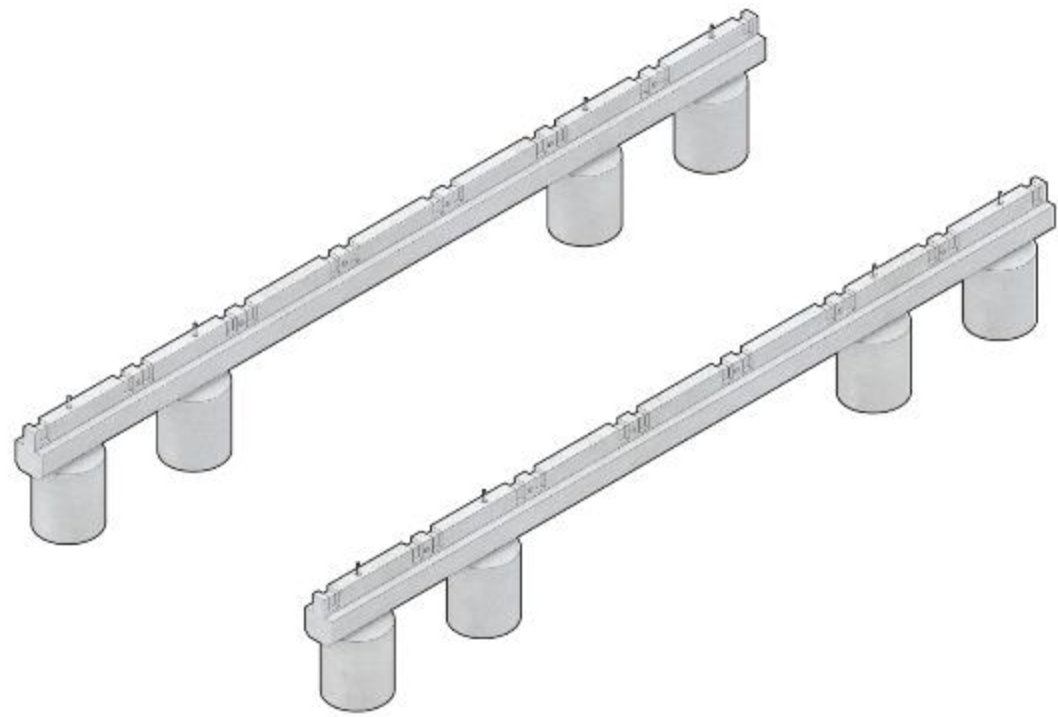
Deck





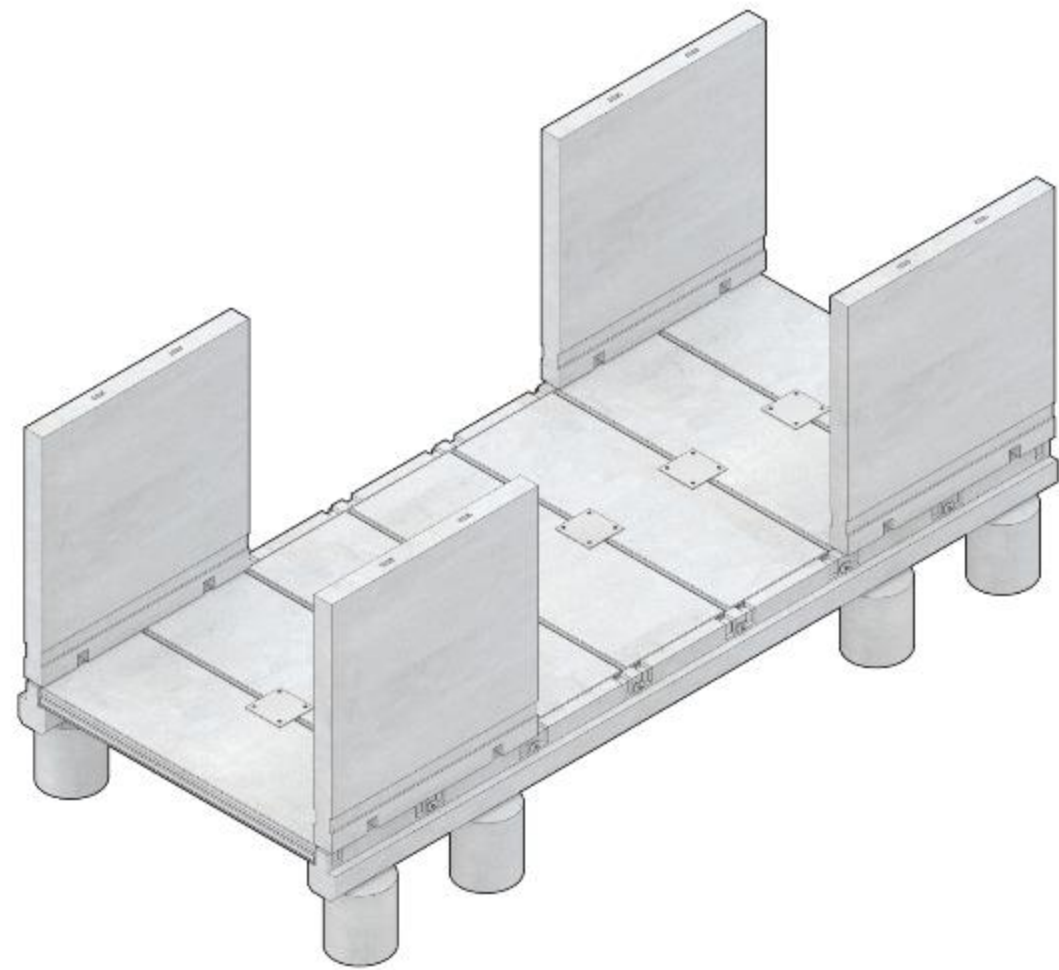


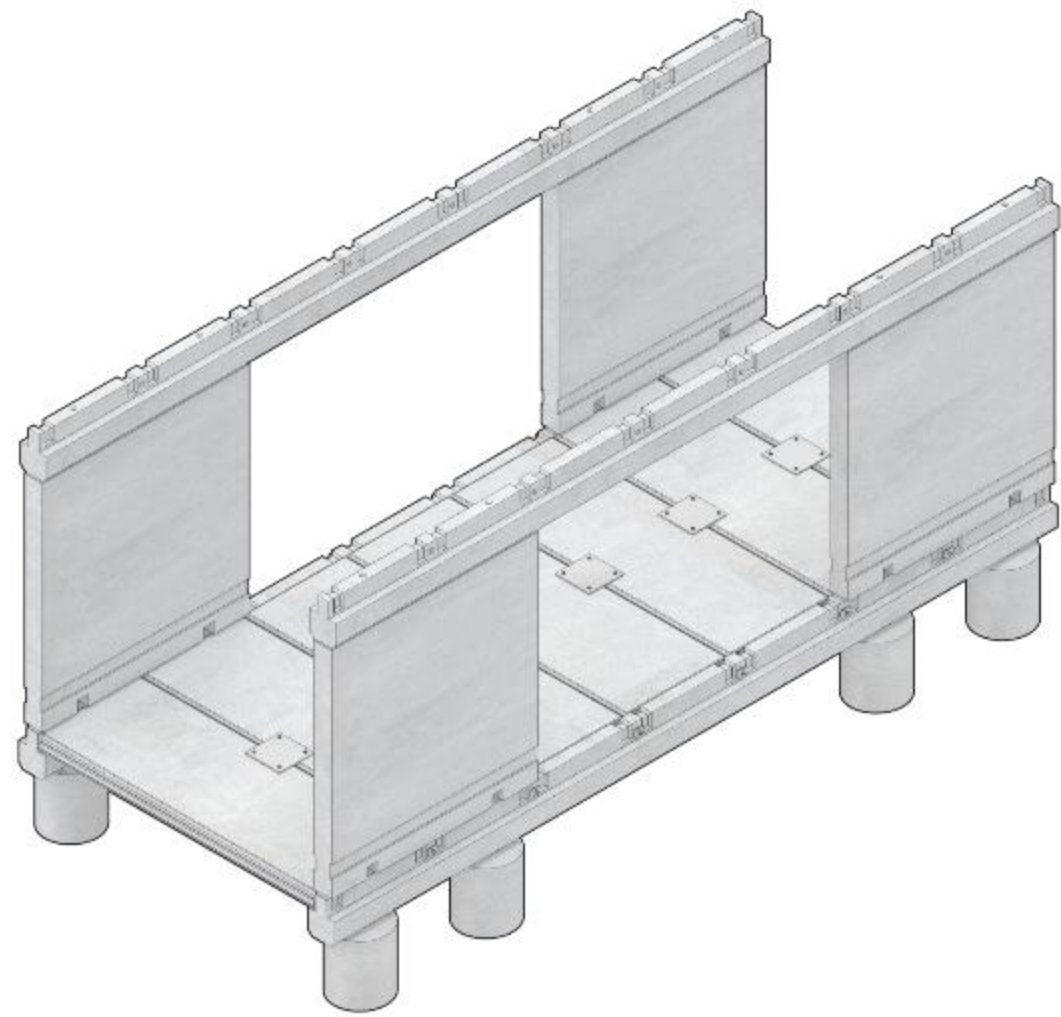


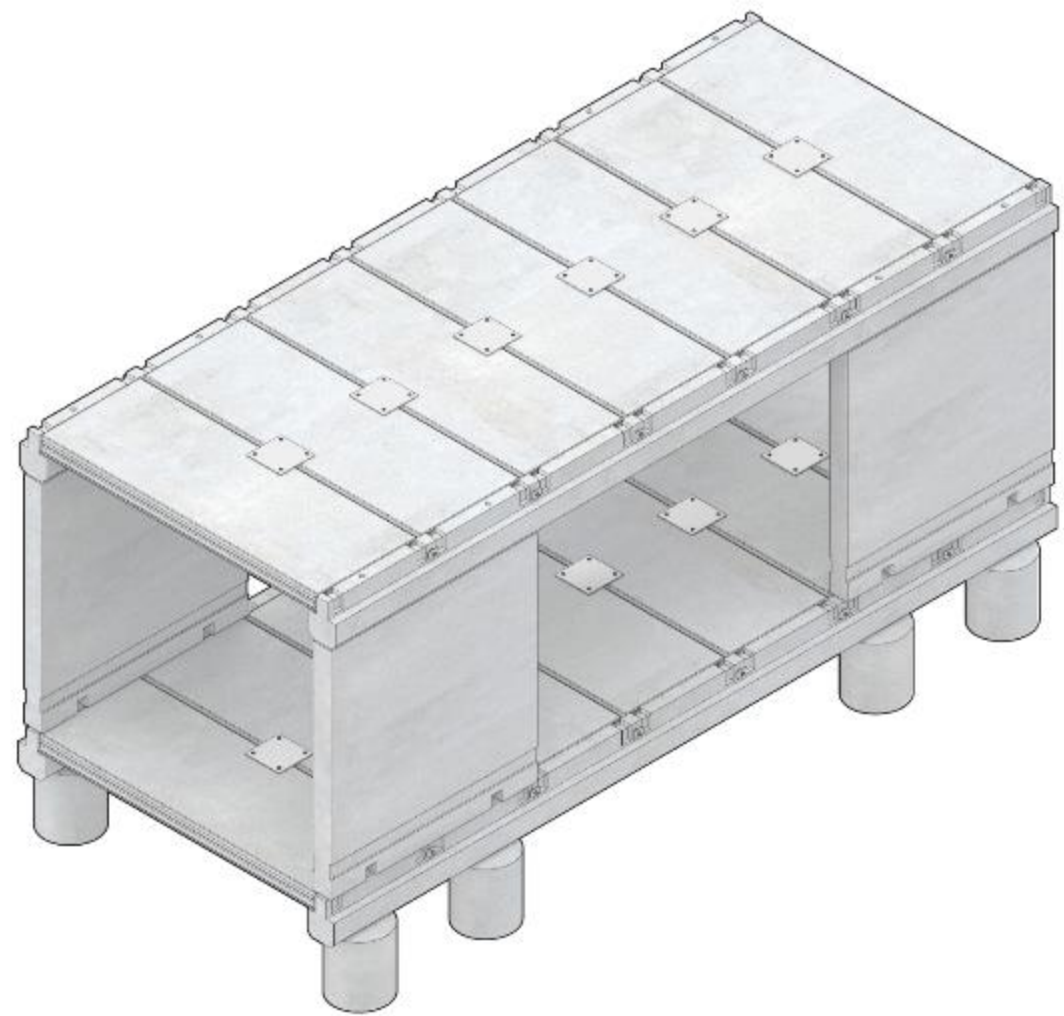












## Exposition / Exterior



**FACADE 1 /**  
**Recycled plastic bags fabric /**  
Bureau SLA & Overtreders W



## Exposition / Exterior



**FACADE 2 /**  
**Recycled bricks tiles /**  
Komponent

**FACADE 2 /**  
**Recycled burn wood /**  
Komponent





**FACADE 3 /**  
**Cork Panels /**  
Amorim Isolamentos

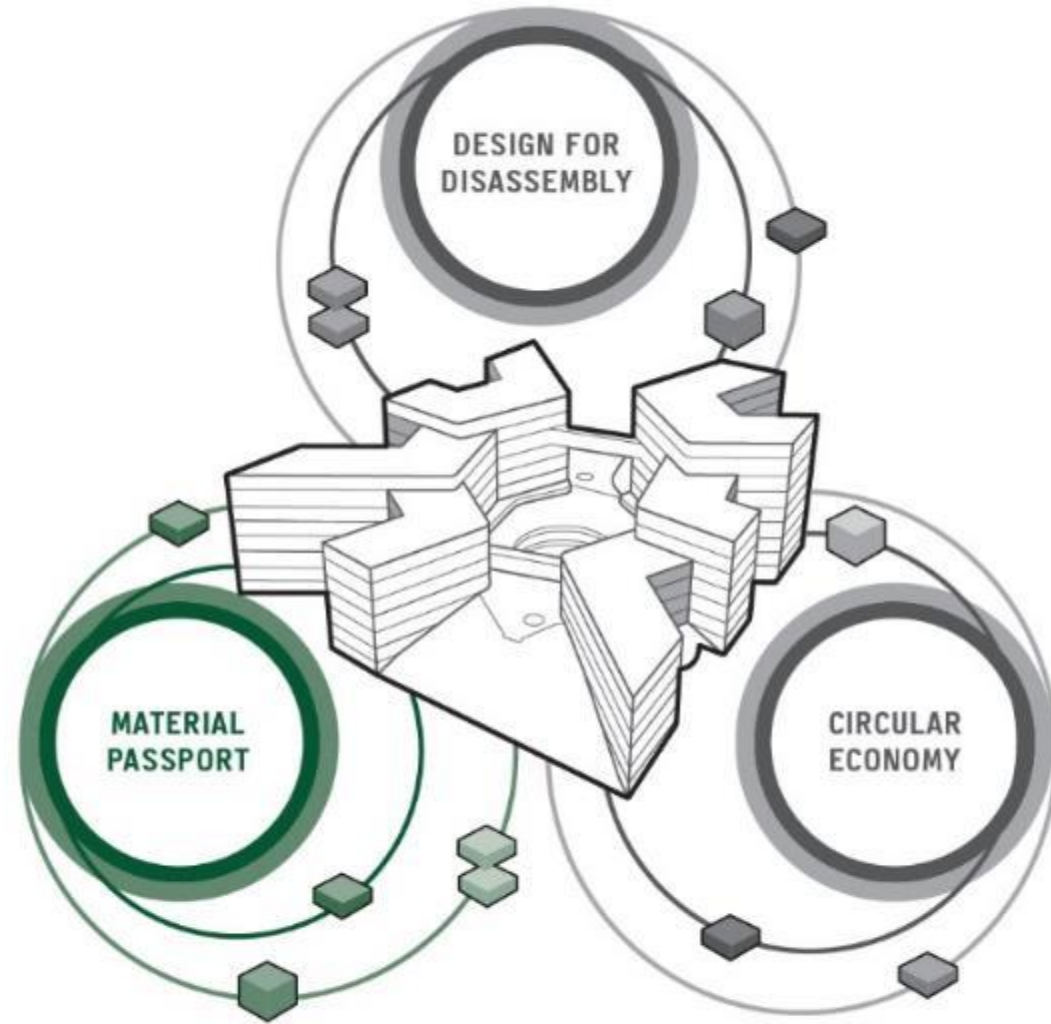






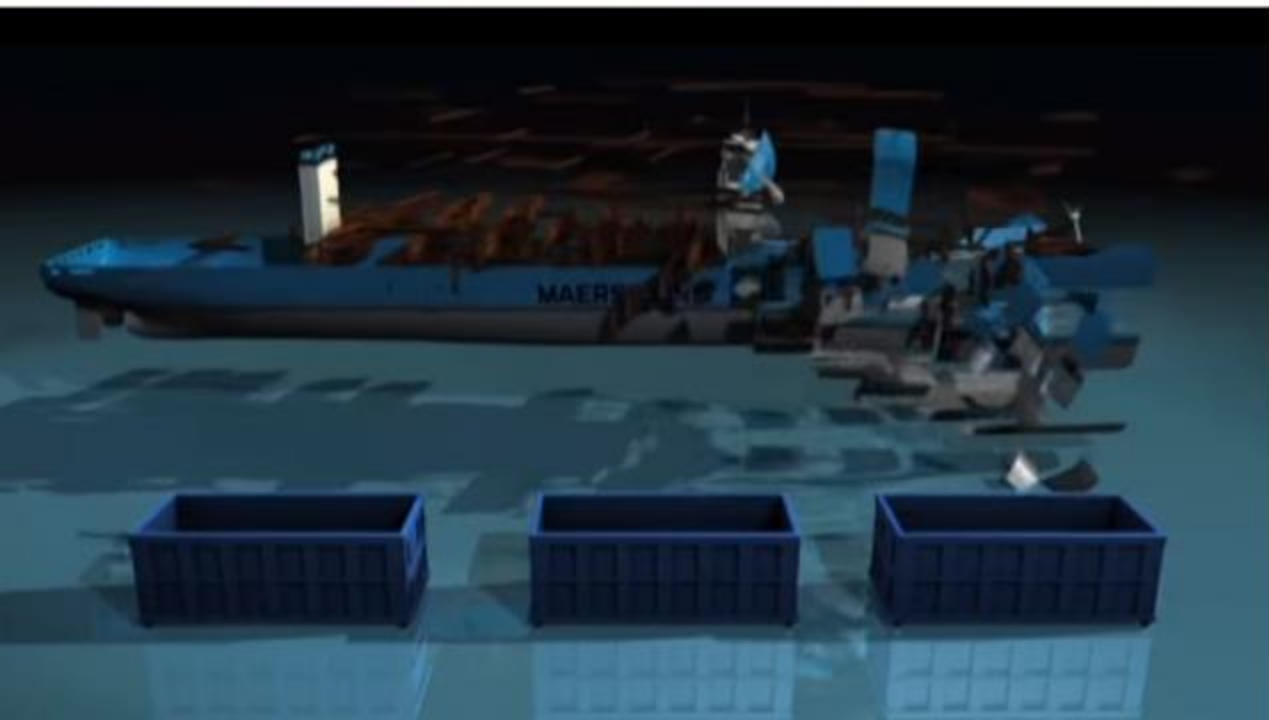
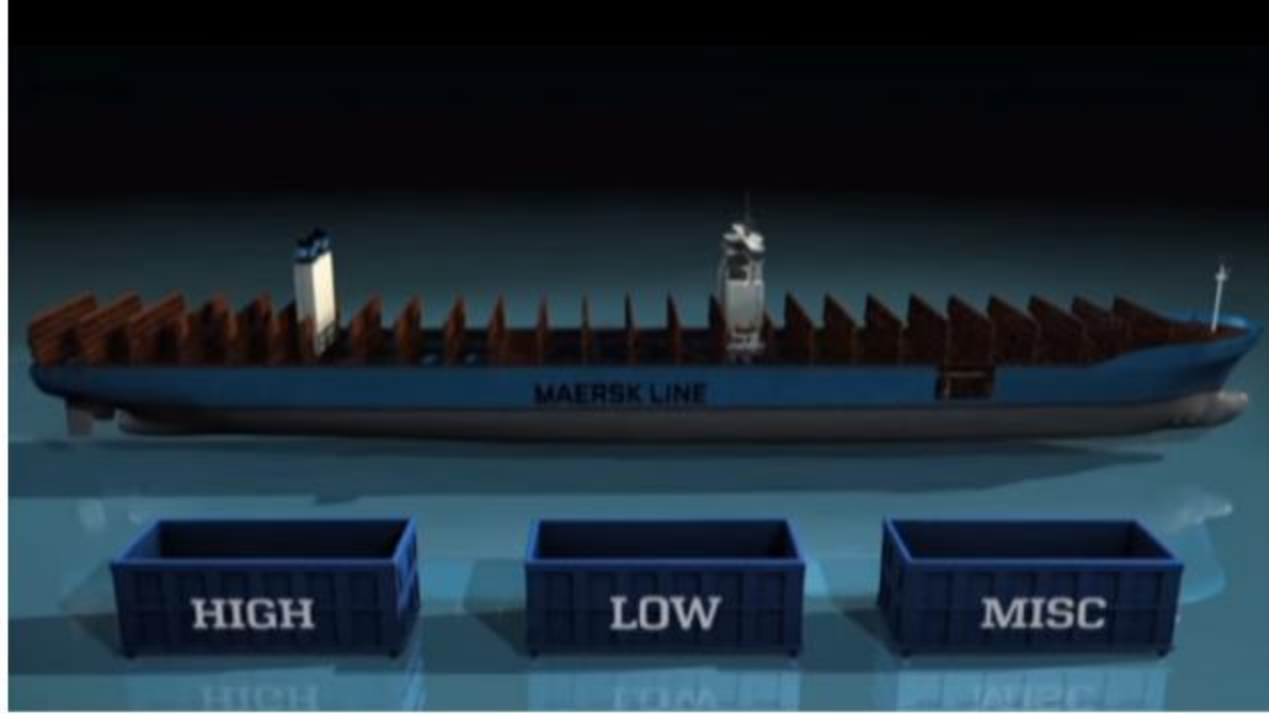






MATERIAL PASSPORT





3D

4D

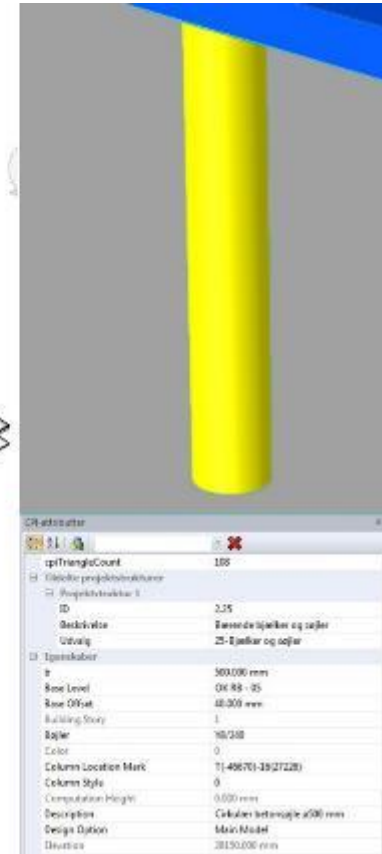
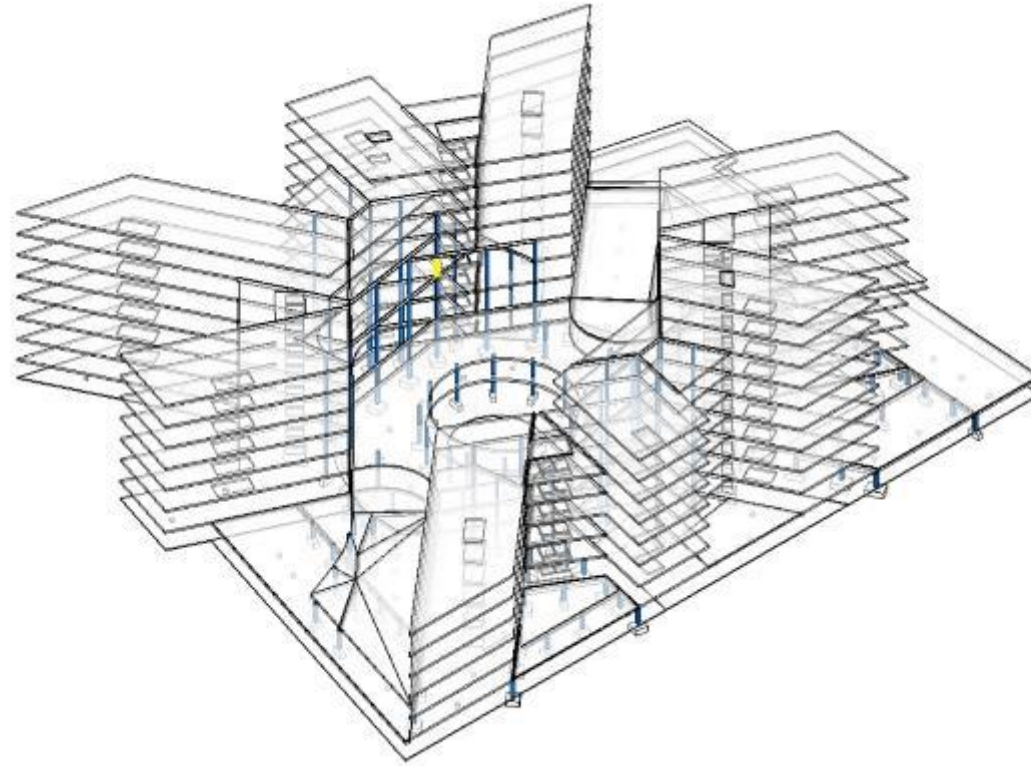
5D

6D

Virtual Design & Construction









1: HEIGHT



2: WIDTH



3: DEPTH



4: TIME



5: ECONOMY

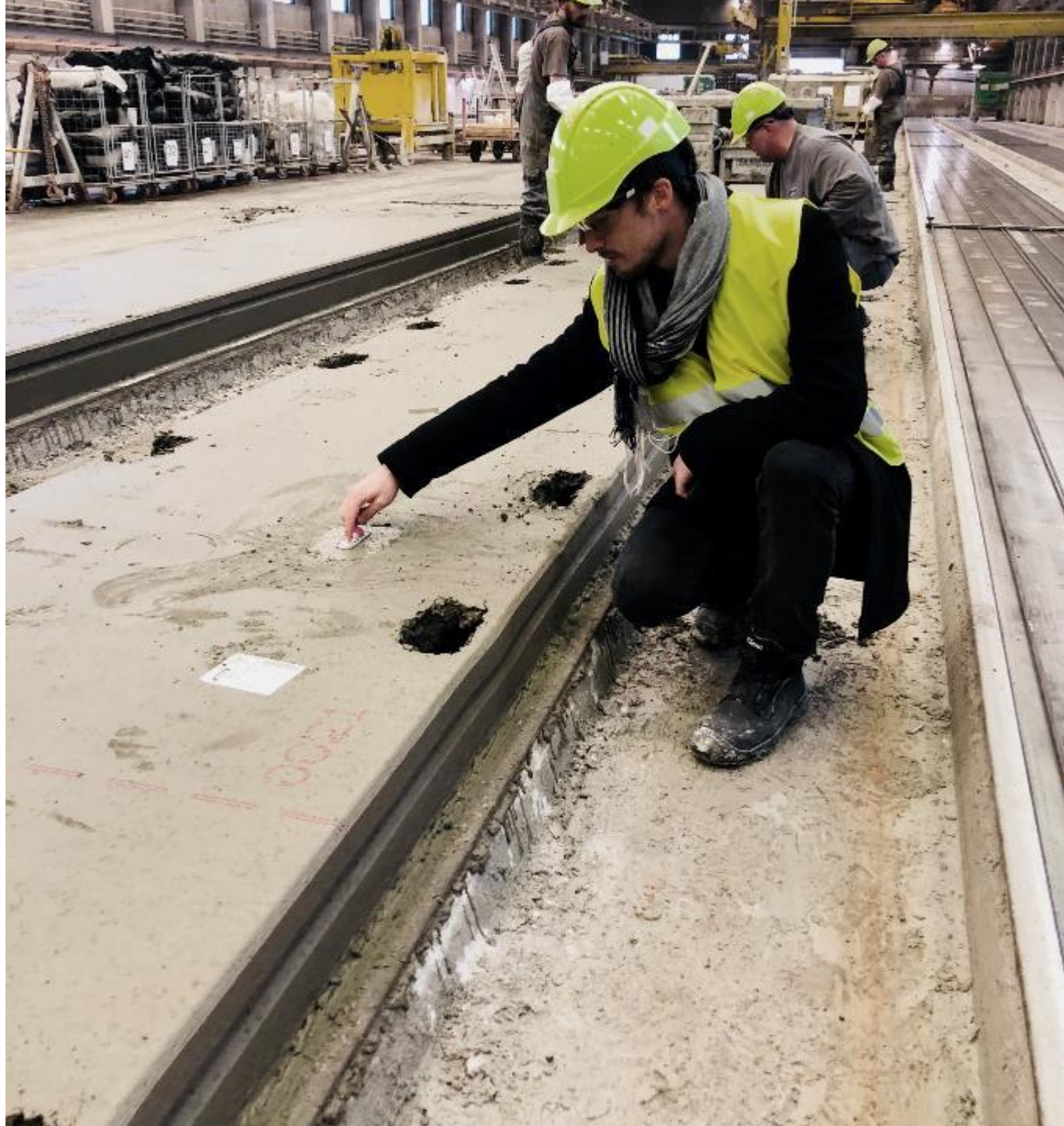


6: OPERATION



**7: REUSE**





10198  
86101

Material **Google**

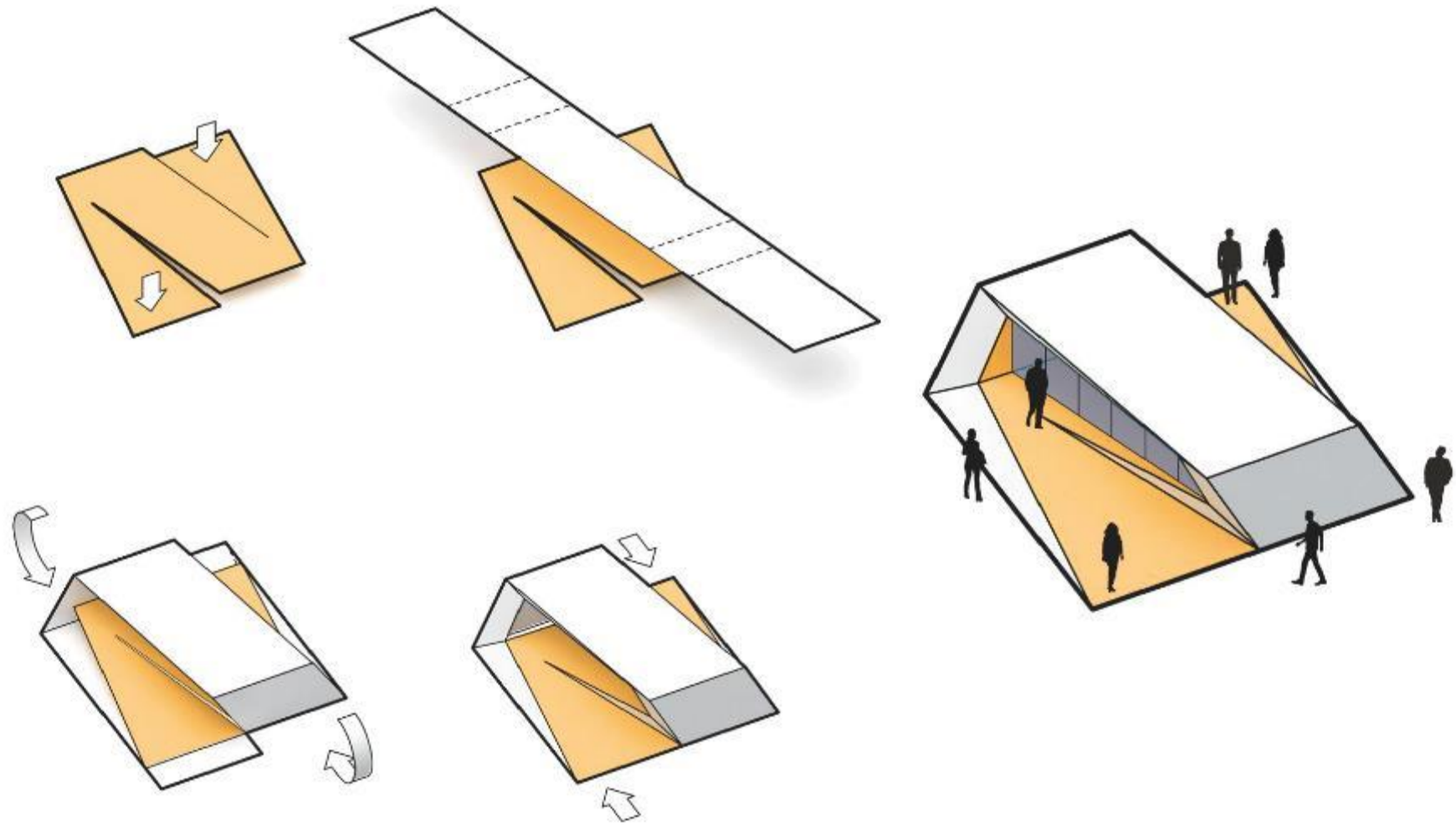
# circularity lab

Google

ARUP

3X11  
GX11















**Thank you!**

Kasper Guldager Jensen, [kgj@3xn.dk](mailto:kgj@3xn.dk), +45 61201784